POWER

A McGRAW-HILL PUBLICATION—ESTABLISHED 1884
ELY C. HUTCHINSON, *Editor*

Volume 73 NEW YORK, JUNE 23, 1931 *Number 25*

Change

I HAVE been looking over the old files of *Power*. They are reminiscent of the steam plant of a third of a century or more ago.

The fundamental of power plant practice was the steam engine. A power plant without an engine was unthinkable. Of its makers there were many. *Power* bristled with advertisements of them and with articles about them.

I picked up a recent issue. In the What and Where to Buy Section there were listed only three makers or distributors of steam engines.

Of the many other standard articles that made up the comparatively simple plants and furnished subjects for the reading columns and support for the advertising of such papers as *Power*, few are in evidence, at least with their old individuality and importance.

An old-time engineer, then in active practice but since passed away, asked me a while ago if the injector was still used in stationary practice. In the recent number to which I have referred there are listed three makers. But the injector is now employed more as an auxiliary feed or as an insurance against failure of the feed pump.

And the modern steam plant is as different from the steam plant of that time as are the pages of the current *Power* from those of its early days.

A friend told me recently of an observation of an old teacher of his. I cannot repeat his language, but it was to the effect that there is one thing that can be counted on with certainty, and that is that things will not continue as they are.

In a few years things will be so different, and yet we go on planning and building our lives as though present conditions were to continue indefinitely.

Fortunate is he who can extrapolate the experiences and developments of the past and not only realize that the setting is shifting but get a glimpse of what the future has in store.

F. R. Low

EDITORIALS

Jobs That Need Consulting Engineers

THERE IS, among engineers, a certain complacency and tendency to self-satisfaction with the general esteem into which the profession has grown in the past score of years.

In many respects the record of achievement justifies this, but in others the benefits of engineering erudition are still sitting on the doorsteps with insufficient interest or courage to ring the bell. The number of industrial power plants still conducted on the penny-wise and pound-foolish plan is a sad commentary on present engineering and its money-saving possibilities. Not long ago an owner of a factory proudly pointed out that his power cost practically nothing because the machinery was fifty years old, rebuilt thirty years ago and had long been amortized. There is no doubt the man really believed what he said. He closely watches the improvement of machinery for his factory, but seemingly knows little and cares less about the economies which will result from modernization of his power plant. His case is typical of a surprisingly large number.

If, then, the consulting engineers will take these cases seriously and carry their messages out to plants of this type they will not only defend their profession, but will find a fertile field for their spare time.

Infiltration Losses in Steam-Generating Units

IT IS COMMON to have considerable excess air filter through ordinary brick boiler settings. With the introduction of plastic preparations and steel casing for boilers the problem appeared to have been solved. However, recent tests of boilers with economizers and air heaters indicate that there may still be considerable leakage of air into the combined unit. On one test of a large boiler, having both economizer and air heater, the flue gases leaving the boiler contained 14 per cent CO_2, while the same gases leaving the economizers contained 12.1 per cent CO_2. This was further reduced to 9.2 per cent CO_2 in the gases leaving the air heater. At the same time oxygen leaving the boiler was 5.3 per cent, that leaving the economizer was 7.4 per cent, and the oxygen content in the gases leaving the air heater had almost doubled to 10.4 per cent. These figures indicate relatively large leakage of excess air into both economizer and air heater.

Such excess air is highly undesirable. It dilutes the flue gases, reduces their temperatures, decreases the rate of heat transfer in both economizer and air heater and lowers the over-all efficiency. At the same time it increases the volume of gases to be handled by the induced-draft fan and thereby adds to the auxiliary power demand.

From every standpoint it is advantageous to reduce this leakage. It would seem possible so to modify the construction of the whole unit to at least greatly reduce this loss. This seems a fruitful field for study and research. It is a preventable loss and the savings would justify some expense.

Guard Against Fires in Oil-Filled Electrical Equipment

FIRE is an ever-present hazard in the operation of electric equipment, and when oil is present the danger is intensified. Possibility of fires in oil-filled equipment and the difficulty of extinguishing them are probably not as appreciated as they should be. A recent report on fire protection of large oil-filled electrical equipment by the Canadian Electrical Association's electrical apparatus committee is worthy of serious consideration by operating engineers. It shows that oil fires frequently do damage in excess of the value of the equipment in which fire started; most of the fires could not be extinguished; and portable-type fire-fighting equipment ordinarily provided is inadequate to extinguish oil fires.

These are conditions that cannot be ignored. Eight companies reporting to the committee record twelve oil fires, which indicates that such fires are not unusual. They occurred in all types of oil-filled equipment and resulted from both external and internal causes, in many cases under conditions which were preventable by proper construction and inspection.

A conservative study of nineteen oil fires showed an average property damage estimated at more than fifteen thousand dollars each, a loss that, at small cost, could have been eliminated or greatly reduced. Outstanding among the conclusions expressed in the report is the statement that a large percentage of the damage done could have been prevented by an adequate drainage system for carrying away the burning oil.

The fact that many of the fires continued to burn until the oil was consumed, notwithstanding the use of portable chemical and other types of fire-fighting equipment, indicates that this class of apparatus can not be relied upon. Portable fire-fighting equipment has its place and prevents many minor fires from becoming conflagrations, but when large volumes of oil are ignited other methods are necessary to expeditiously handle the situation. These are simple and can be provided at low cost. One is to drain the oil away quickly from the equipment in difficulty. After this has been done any remaining fire can be effectively handled by the portable fire-fighting equipment.

A study of the important findings in this report, given in this number, should provide operating engineers with a helpful background of experience from which to consider the oil-filled equipment in their plants and make certain they are adequately protected. A serious fire hazard will then be eliminated.

Welded Boiler Drums And Embrittlement

MUCH has been printed concerning the embrittlement of boiler drum metal. It is generally attributed to high concentration of caustic soda in the presence of highly stressed metal. In the riveted drum, boiler water sometimes seeps in between the seams, where caustic concentration may become sufficiently high to cause embrittlement troubles. It is contended that embrittlement troubles will disappear if such concentration can be prevented. Drums that have no seams apparently will eliminate the opportunity for accumulations of high caustic concentration to exist. Forged drums have been in service for some time, and, although exposed to water that might be expected to cause embrittlement, no evidence of it has been found.

The recent installation of a fusion-welded drum at the Brown Paper Mill Company, described in the June 9 number of *Power,* presents an excellent opportunity to test again the theories concerning embrittlement. The boiler water at this plant has been of such character as to cause embrittlement, and the welded drum replaces a drum condemned because of an embrittlement crack. Other welded drums are being installed at plants in Michigan and Tennessee.

The performance record of these drums will be of great value, and it is hoped that the results will be made available to power engineers.

Power Budgets

BUDGETS have demonstrated their usefulness as tools of business management, but their application to the power services has not been as extensive as would seem desirable.

To be of value the power budget should be prepared on a departmental basis, keeping individual responsibilities sharply separated. The manager of a factory department may reasonably be expected to specify the maximum number of kilowatt-hours and the maximum weight of process steam he will require per unit of product, but he cannot be held accountable for variations in the unit cost of producing that steam or electricity. Such unit costs are the responsibility of the power engineer.

For these reasons it is clear that a power budget should be in several parts and on a unit basis. The primary power budget would be that of the power plant itself, considered as a factory producing power services. This budget would limit the operating unit cost or the total unit cost of each of the power services. It would then be possible, in the budget of each consuming department, to specify the dollars to be expended for power services per unit of product.

While this method of budgeting has much to recommend it, certain objections exist. For example, the factory department reaps the full benefit of any savings made by the power plant. Likewise it is penalized if the power plant exceeds its budgeted unit cost.

A variation, already used by some plants, is to fix, at the beginning of the year, a sales price for each power service. This is generally made large enough to exceed the expected cost by a small margin. The margin represents profit in power plant operation, and the fact that it can be increased by careful operation gives the engineer a definite incentive. The existence of such a fixed sales price permits the consuming departments to budget their power service costs with the assurance that the unit costs will not change during the fiscal year.

These ideas are presented, not as the final word on the subject of power budgets, but as suggestions. Ideas and practices of readers having experience along this line should be of interest to all power executives and are invited by the editor.

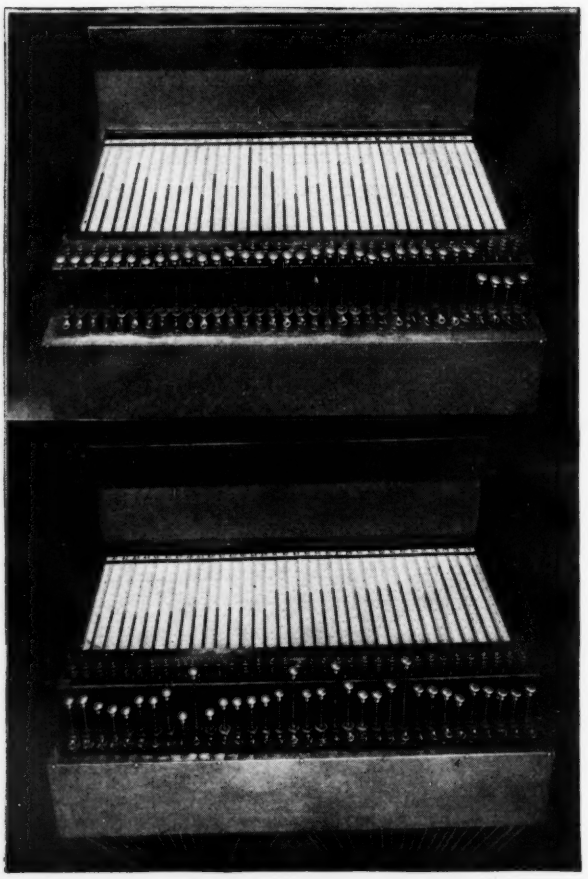
▼

POWER Stands for . .

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**
8. **Prevention of Smoke, Within Reason**

▼

Zone Air Control for Underfeed Stokers Increases Boiler Capacity



In the upper photograph, with all the zone dampers wide open, notice the wide difference in relative air flow as indicated by the gages. In the lower view the air distribution is well balanced, in many different positions

▼

THE FUEL BED is divided into zones, each zone into sections the width of one tuyere. Each section has a manually operated control damper and a venturi metering throat, so that the operator is able to maintain a predetermined distribution of air regardless of variations in fuel-bed resistance

By ARTHUR S. GRISWOLD and EDMUND M. BROWN
The Detroit Edison Company

IN UNDERFEED STOKER practice the usual arrangement for supplying air to the fire consists of a plenum chamber beneath the entire stoker in which a positive pressure is maintained. The air finds its way through the tuyères and fuel bed with presumably fairly equal distribution throughout, but actually in a very uneven manner, depending upon variations in fuel-bed resistance.

The Detroit Edison Company made some attempts at damper control of sections of the fuel bed and is using at Delray an automatic air distribution control supplied by the stoker manufacturer.

When No. 4 boiler was installed at the Beacon Street heating plant in 1929 the stoker was equipped with a new arrangement of manually operated air control in which the fuel bed is divided into zones and each zone divided into small areas, to each of which the air supply is metered and controlled. The operator is thus able to maintain a predetermined distribution of air regardless of variations in fuel-bed resistance.

Boiler 4, at Beacon Street, in most respects is a duplicate of Boilers 1 and 2.[1] The unit is W-type, five-drum, bent-tube, containing 2,616 tubes of 3¼ in. diameter. It has 41,500 sq.ft. of heating surface, and the furnace volume excluding the pit is 16,300 cu.ft. There are no economizers or air preheaters. The boiler is fired by two 14-retort Taylor underfeed stokers set facing each other and discharging their refuse into a common pit. The stokers, with 29 tuyères in each stack, are equipped with both moving and fixed extension grates. They have a projected grate area of 636 sq.ft., including the ashpit. Refuse is removed from the pit by independently driven clinker crushers 18 in. in diameter.

Air-Control Apparatus

Each stoker is divided into three zones extending the full width of the stoker. The upper zone is 17 tuyères deep; the lower zone is 12 tuyères deep; and the extension grates comprise the third zone. Each zone is, in turn, divided into sections of the width of one tuyère,

[1] See *Power*, Nov. 23, 1926.

and each section is provided with a control damper and a venturi metering throat. Air for combustion is delivered by a forced-draft fan to a plenum chamber which extends under the entire stoker, from which it passes successively through the metering throats, damper boxes and tuyères into the fuel bed. A differential gage indicates the quantity of air passing through each of the venturi throats, the gage being calibrated to show the relative quantities of air flowing. These readings can be multiplied by predetermined constants to give the actual quantities of air in cubic feet per minute or other desired units, but for ordinary use only the relative quantities are needed.

Additional metering throats, four on each side of the double stoker, measure the air supplied to the extension grates. Thus provision is made for measuring and controlling all of the air entering the fuel bed through the tuyères and grates. The measuring throats for the upper 17 tuyères are called the upper throats, those for the lower 12 tuyères the lower throats and those for the extension grates the extension-grate throats. Altogether there are 68 throats, 30 upper, 30 lower, and 8 extension-grate.

Differential gages are grouped on two special panels, each containing 34 inclined tubes, enough for all throats on one side of the double stoker. All tubes have a working range of 1 in. of water. A common line to a draft tip in the plenum chamber provides the static pressure connection to all tubes, while individual pipes lead from each vena contracta to its respective gage tube.

Dampers are regulated manually from the boiler operating floor. A convenient means devised for doing this uses wires which slide in flexible tubes. With this device the damper controls may be directly in front of their respective gage tubes and the boiler operator can observe readily the effect produced while he is making adjustments.

To insure readable differential gage deflections over the wide range of air flows required, it has been necessary to provide a means of changing the size of the venturi throats. The throats are rectangular in shape, the two ends being flat and the two sides curved to form the throat section. One side is hinged at the top and has a close sliding fit between the end plates, while the other side is stationary. These hinged sides of all throats of a similar group, such as the upper throats of either stoker, are attached to a common rod which can be moved, thus making the throat area large or small, as conditions may require, and bringing the differential heads within the range of the gage scale. All throats of each group being attached to a common rod, the same adjustment is made to each.

A complication exists in this installation because of the fact that the stokers have air-cooled, refractory-covered, cast-iron protection plates in the wall immediately above the tuyères and ram caps. Air for cooling the plates is supplied through the upper throats in the manner shown in the perspective view. It will be noticed that the duct above the throat is divided into two parts, the larger, containing a manually controlled damper, leading directly to the tuyères, and the smaller to the air-cooled casting. Keeping the damper in the larger passage partly closed creates a difference in air pressure, which causes a flow of air through the small duct, the air-cooled castings and thence to the tuyères. The air-cooled castings are not a part of the control system, but affect the design of this installation because of the need of maintaining a continuous flow of air through them.

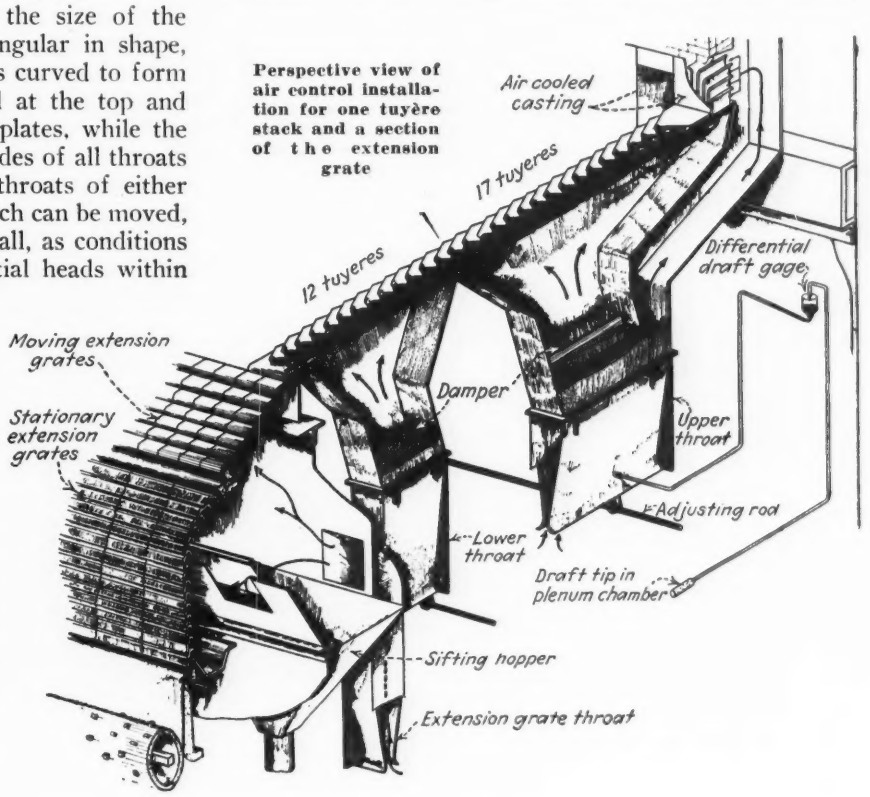
Operation

Operating the control, all that is necessary is to maintain approximately equal air flow indications on all of the gages of each separate zone. Because the throats are of the same size, equal deflections indicate the same quantities of air going to each of these sections of the fire. If the gages do not show equal deflections, the dampers are adjusted until they do.

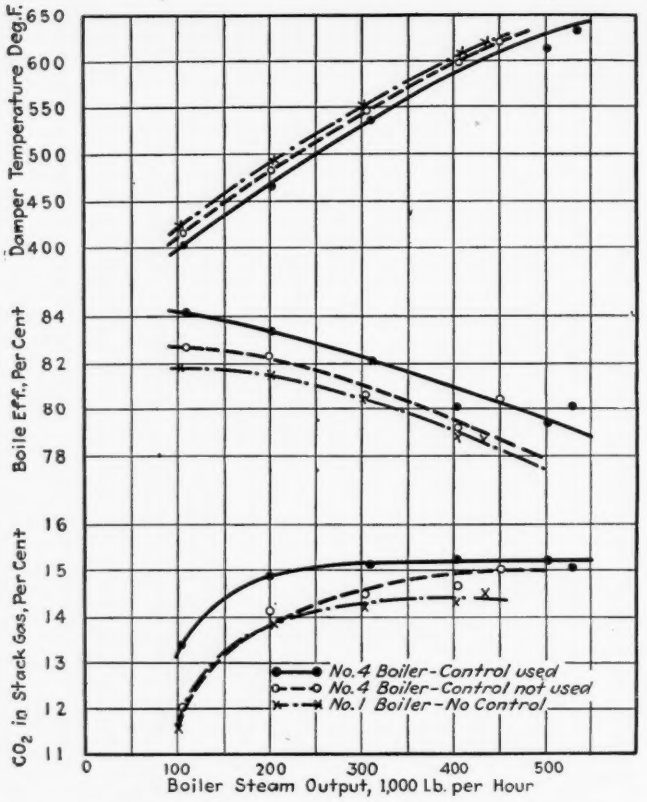
With boiler loads of less than 200,000 lb. of steam per hour frequent adjustment of the dampers is not required; a fairly even distribution can be maintained by adjusting them at about ten-minute intervals. As the boiler loads increase above this amount more frequent attention is necessary, but no more than can be given easily by the regular operator.

A series of tests and several months of operating experience have demonstrated that the control has many valuable features. Probably the most important is that this boiler can produce continuously 535,000 lb. of steam per hour, nearly 25 per cent more than can the other boilers with stokers of the same size but not equipped with the air control. This will be appreciated when it is considered that the installation of the control system on the four boilers now in the plant will provide as much additional steam-generating capacity as will an additional boiler.

The limit to the boiler steam output is the inability to maintain a uniform fuel bed and prevent it from being torn to pieces by the blast of air leaving the tuyères. The zone control makes it possible to check any locally excessive air flow and to increase any locally deficient air flow. Thus it is possible to maintain a uniform



Perspective view of air control installation for one tuyère stack and a section of the extension grate



Curves showing improvement in boiler performance produced by zone air control

fuel bed up to much higher steaming rates than is possible with the boilers having the older type of control.

Opening up of holes in the ordinary fuel bed is a cumulative process which probably progresses as follows: The distribution of the air flowing through the fuel bed is governed partly by the fuel-bed resistance. An area of slightly low resistance, caused perhaps by lack of homogeneity of the fuel, permits a slightly increased flow of air. This locally increases the combustion rate, the fuel bed burns still thinner, and the air flow further increases until a hole in the fire results. Once established, the blast of air through it prevents its closing.

With no limitation imposed by insufficient capacity of the auxiliaries or by the boiler itself, the amount of coal which can be burned depends upon the ability of the stoker to handle it, and the limiting point is that at which the coal no longer can be kept in a reasonably uniform bed. The air control, by preserving the uniformity of the fuel bed, raises this capacity limit considerably. Without the control, blowing of pieces of coke from the bed and formation of huge drifts occur at a much lower combustion rate. Of course, even with the air control in operation the point ultimately must be reached at which it is impossible for the fuel to lie on the stoker because of the lifting effect of the air blast.

Increased Capacity and Efficiency

Burning a Kentucky coal[2] of high grade, the maximum continuous capacity obtainable on test, in pounds of coal per square foot per hour, was approximately: without the air control, 65; with the air control, 78.

At the higher coal-burning rate a considerable quantity of partly burned coal of the size of rice and pea was carried over into the boiler passes, but caused no trouble, effective methods having been developed for removing it. No appreciable amount of cinder was blown out of the stack.

Boilers at this plant are not equipped to run weighed water and coal tests, but the boiler efficiency can be determined approximately by a heat balance when the combustion losses are computed. The effect which the air control has on combustion and boiler efficiency was determined in this manner, it being assumed in all cases that the radiation and unaccounted-for losses were $2\frac{1}{2}$ per cent of the total heat in the fuel. On tests, the CO_2 in the gas leaving the boiler was from $\frac{1}{2}$ to 2 per cent higher when the zone control was used. As will be anticipated, lower exit gas temperatures result from the higher CO_2, and these two improvements give appreciably higher boiler efficiency. In spite of the low load factor of these central-heating-plant boilers this improvement in boiler efficiency is sufficient to make the cost of the installation a profitable investment even if the increase in boiler capacity is not considered.

Tests Demonstrate Value of Control

That the improvement in combustion and boiler efficiency is the direct result of improved air distribution has been demonstrated by close observation of the differential gages. During many tests the boiler has been operated without using the control, that is, with the dampers in fixed positions. In these cases the gage readings vary continuously, often indicating that the quantity of air used by adjacent tuyère sections differs by over 50 per cent. Since the coal is supplied at a uniform rate to all sections, this variation in air quantities indicates that certain sections of the fire were receiving an excess of air, while the supply to other sections was deficient. This probably represents the actual conditions in any large stoker with no definite means of controlling the air distribution. The rapidity with which the air distribution changed also was shown strikingly by the gages.

By operating the section damper it is possible to maintain a nearly uniform distribution of air. This point is illustrated by the two photographs of one of the differential gages shown on p. 980. In the one case all of the control dampers are wide open and the gage readings differed widely. In the other the gage readings are uniform, but the dampers, as indicated by the damper controls, are in many different positions.

Naturally there are certain limitations to a device of this sort. Occasionally, owing to a clinker formation or some other cause, there may be a spot where the air flow is deficient and the widest open position of the damper will not suffice to force the desired amount of air through it.

An interesting and surprising discovery was that apparently but 50 to 60 per cent of the total air required for combustion is measured by the metering throats. The remainder evidently reaches the fuel bed by leaking around the secondary pushers and through various other openings. This is not necessarily a detriment, particularly since the air is not preheated; but it was rather unexpected.

Distribution of the air to the various sections of the fire differed greatly from that expected. With high fuel-burning rates, over 50 per cent of the measured air was supplied to the extension grates. From the construction of the stoker, it is reasonable to expect that about one-half of the unmeasured air also was going to that part of the fire. Thus about one-third of the fuel bed

[2]The analysis (dry) was: fixed carbon, 56.15; volatile, 34.25; ash, 9.60; B.t.u. per lb., 13,530; fusion point of ash, above 2,460 deg. F.; moisture as fired, 2.62 per cent.

was burning about one-half of the coal. It is probable that the coal was thoroughly coked before reaching this part of the fuel bed and was therefore able to stand high air velocities without being blown out of place.

It was found also that the best combustion results are produced when slightly more than twice as much air is supplied to the lower twelve tuyères as to the upper seventeen. Reducing the quantity of air supplied to the upper tuyères permits of the building of a more active fire at the lower end of the tuyère stacks and on the extension grates. Proper control of these conditions has produced improved combustion results.

Although the use of the control requires considerable attention from the operator, the convenient arrangements seem to make it quite within the ability of a well-trained man to handle two boilers of this size.

▼ ▼ ▼

Banding Wire Sizes for Armatures and Rotors

By A. C. ROE

WHEN REBANDING a repaired or rewound armature, it is often desirable to have at hand data that will enable one to determine the size of banding wire to use, the width or number of turns per band, the number of and spacing of clips, and the thickness of clips. This data can, in the majority of cases, be obtained when stripping the armature, but when that information has not been recorded the tables in this article will enable anyone to select suitable bands for direct-current armatures and alternating-current rotors.

Table I gives the diameter of a hard-tinned steel banding wire to be used for armatures or rotors of various diameters, the third column giving the spacing of the locking clips. For example, an armature 20 in. in diameter would require 0.064-in. banding wire, with clips

TABLE I—SIZE OF BANDING WIRE AND CLIPS

Diameter in Inches		Clip	Clips	
Banding Wire	Armature	Spacing, Inches	Material; Thickness in Inches	A
0.029	Less than 10	4	0.005 tinned sheet copper	22
0.045	10 to 16	5	0.013 tinned sheet steel	80
0.064	16 to 24	6	0.013 tinned sheet steel	160
0.081	Above 24	8	0.*013 tinned sheet steel	180

*Where possible use 0.022-in.-thick tinned sheet steel. All clips can be ½-in. wide and ½ to 1 in. longer than the band's width. Vary coil-end band's width in ¼-in. steps.

spaced 6 in. apart. There would be $3 \times 20 \div 6 = 10$ clips per band, spaced 6 in. apart. Column 4 from the left indicates the thickness and kind of material, which in this case would be 0.013-in. thick tinned sheet steel. Steel is used because it tends to reduce band eddy currents. Column A contains factors that are used to estimate the number of turns or widths of bands, as will be explained later.

On armatures above 20 in. in diameter clips 0.022 in. thick should be used if space permits. All clips can be made ½ in. wide and ½ in. to 1 in. longer than the width of the band. All coil end bands can be varied in width in ¼-in. steps. The width of core bands is limited either by the width of band grooves or by factors that reduce eddy currents to a minimum. One safe rule is: Do not make any core band wider than ⅜ in.; if a wider band is required make it in two or more sections and insulate the sections from each other with mica or asbestos.

The number of turns or width of bands can be determined by using the factors in Tables I and II and the formula $N = \frac{D \times W \times B}{A}$, where N is the number of turns in each band, D the armature diameter in inches, W the weight of the coil end in pounds and A and B are factors given in Tables I and II. Using Table II, overspeed r.p.m. values should be used. If these are not known increase the normal r.p.m. value 25 per cent. For wound rotors of induction motors use the normal speed value.

To determine the width of bands the total weight of the coil ends must be known. It can be assumed that the ends are 80 per cent of the weight of a complete set of coils. Then each end of the winding has a weight equal to one-half of 80 per cent of the total of a set of coils, and is W in the formula.

TABLE II—BAND STRESS FACTORS

R.p.m.	100	150	200	250	300	350	400	450	500
B	0.023	0.051	0.090	0.14	0.20	0.28	0.36	0.46	0.57
R.p.m.	550	600	650	700	800	900	1,000	1,100	1,200
B	0.68	0.81	0.96	1.11	1.45	1.83	2.26	2.74	3.26
R.p.m.	1,400	1,500	1,600	1,700	1,800	2,000	2,400	3,000	3,600
B	4.43	5.09	5.79	6.53	7.33	9.05	13.03	20.35	29.3

Assuming a 24-in.-diameter armature with a total coil weight of 150 lb., normal r.p.m. = 600. The width of the band is found as follows:

The size of wire from Table I is equal to 0.064 in., the clips are spaced 6 in. apart, and there are $3 \times 24 \div 6 = 12$ clips per band. The weight of the coil ends $= 150 \times 0.80 = 120$ lb., or each end equals $120 \div 2 = 60$ lb. The speed in r.p.m. $= 600 \times 1.25 = 750$. From Table II it is found that $B = 1.45$, as 800 r.p.m. is the next highest value given above 700. Table I gives 160 as a value for A. Then the number of turns of 0.064 in. wire is $N = \frac{24 \times 60 \times 1.45}{160} = 13$. A band $13 \times 0.064 = 0.822$ in., say 1-in. wide, would be used.

The width of core bands can also be determined in the same manner, using the weight of the slot portion of the coils, and dividing the width of band into a number of narrow bands either ⅜ in. wide, single-section or two or more sections insulated from each other.

The use of tie clips that connect adjacent bands together should be avoided. This practice has the effect of a squirrel-cage winding, and sets up eddy currents in the bands tied together.

TABLE III—BANDING-WIRE TENSION

Wire Size, Inches	Wire Size, B. & S. Cage	Tension in Pounds: Wire-Wound Coils	Tension in Pounds: Strap or Ribbon Coils
0.0285	21	100	100
0.0453	17	200	200
0.064	14	250	400
0.081	12	...	550

The correct band pressure or tension to be applied during the banding process is important. Table III gives values for wire-wound and strap-copper coils. The tension varies according to the size of wire, type of coil, etc. The same tension is used on core bands as on the end bands.

Metered Power Services

SPELL ECONOMY IN HOTEL OPERATION

By WARREN D. LEWIS

Chief Engineer
Hotel New Yorker, New York City

Hotel managers and hotel accountants save money by carefully analyzing the cost of food and personal service, only to waste much of it by lumping "light, heat and power" as a single accounting item. Departmental metering of power services is an open road to more profitable hotel operation

WITH a year's operation to look back on, I endeavored to compare the power service data of the Hotel New Yorker with that of other hotels. While I was successful to a limited degree, the results emphasized the lack of records for properly analyzing costs.

In no case was the chief engineer to blame for the lack of complete records in the other hotels; each had analyzed his plant as far as his records would allow. In most cases the lack of meters or recording instruments on important services made it impossible for him to "strike a balance."

When the plant is on paper there may be some question as to the advisability of installing certain meters, but certainly provision can be made for a later installation at minimum cost if found necessary. The main trouble is that the importance of the power services in a hotel is not realized by the designer and builder, or even (many times) by the manager. The idea that the power plant is an integral part of the hotel "business" is not recognized.

For proof of this statement, notice how carefully the costs of rooms and food are checked in a hotel bookkeeping system. Notice also how the power services and maintenance costs are lumped together as if they were simply to be tolerated. At the New Yorker, on the other hand, meters and recording instruments were installed wherever needed to enable the engineers to operate the equipment economically and to obtain the information required by the management for intelligent control. Results have justified the installation of these meters.

The Consuming Departments

The six following power service consuming departments may be listed as typical of the average fair-sized hotel: (1) laundry; (2) kitchen; (3) guest rooms, elevator service; (4) ballrooms, public rooms, etc.; (5) administration offices, locker rooms, work rooms, etc.; (6) concessions, stores, etc.

Consuming departments may often be further subdivided to advantage. In any case each division listed should be charged with its proper share of the cost of the power services rendered.

Services to Be Sold

The engineering department buys coal, water and gas as raw materials and "sells" to the other departments heat, electric light and power, steam, refrigeration, hot and cold water, ventilation, etc. These services can be handled as follows:

1. *Heating*—The heating returns from the vacuum pump can easily be metered and the cost apportioned on a volume basis.

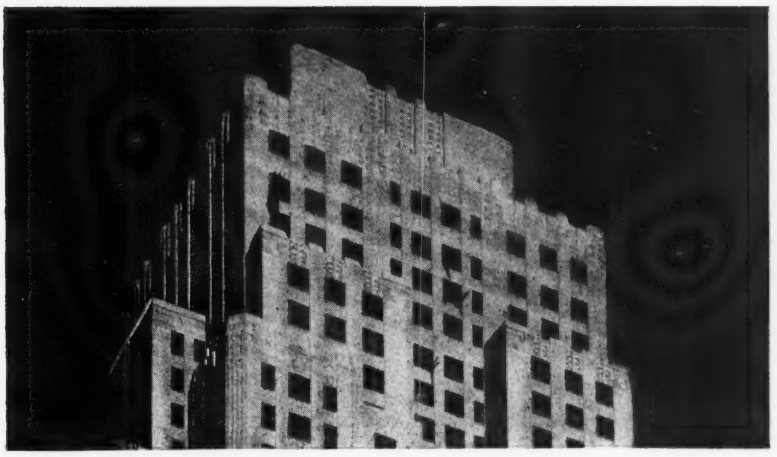
2. *Electric Light and Power*—A properly designed switchboard is needed with a panel for the laundry power, one for the kitchen power, etc., and in a like manner a panel or perhaps a group of switches for the laundry light, another for kitchen light, possibly serveral panels for guest room light, etc. In other words, the electrical requirements of each department should be distributed from a section of the main switchboard where it can all be master-metered.

3. *Steam*—Live steam for the laundry and kitchen can be easily metered at a small initial cost.

4. *Refrigeration*—Motor-driven refrigerating machinery for the kitchen service would receive power from the kitchen power distributing board. Motor-driven air-conditioning equipment used for boiler-room ventilation would be supplied from the ball-room power panel, etc.

5. *Hot and Cold Water*—It is very easy to measure the water used and figure the additional cost of heating it.

6. *Ventilation*—All modern ventilating equipment is motor-driven. By supplying, for example, the current for the laundry ventilating fans from the laundry sub-power panel, the laundry would pay the bill. Other ventilating



equipment would receive its power from the proper sub-power panels.

7. *Gas*—Used almost exclusively by the kitchen, is chargeable there.

Services Consumed by Various Departments

Going back to the typical "parts" of the hotel, consider them and the services they require.

1. *Laundry*—Here we use hot and cold water, live steam, electric light and power, ventilation, possibly sump pumps, etc., but all easily measured and the cost accounted for.

2. *Kitchen and Dining Room*—Same as the laundry with additional gas, refrigeration, air conditioning, etc.

3. *Guest Rooms*—Hot and cold water, electric light, bathroom ventilation, ice water, elevator service, etc.

4. *Ballrooms, Public Rooms*—Electric light, special elevators, hot and cold water, air conditioning, etc.

5. *Administration*—Electric light and power, hot and cold water, ventilation, etc.

There are other services, such as vacuum cleaners, air compressors, pneumatic tubes, etc., which could likewise be operated from the proper sub-power panel.

The initial cost of a switchboard as suggested, with the electric sub-meters, together with water meters, steam meters, etc., mentioned previously, would be a small percentage of the total cost of the power equipment—but what a difference in checking costs.

Operate Power Plant as Separate Establishment

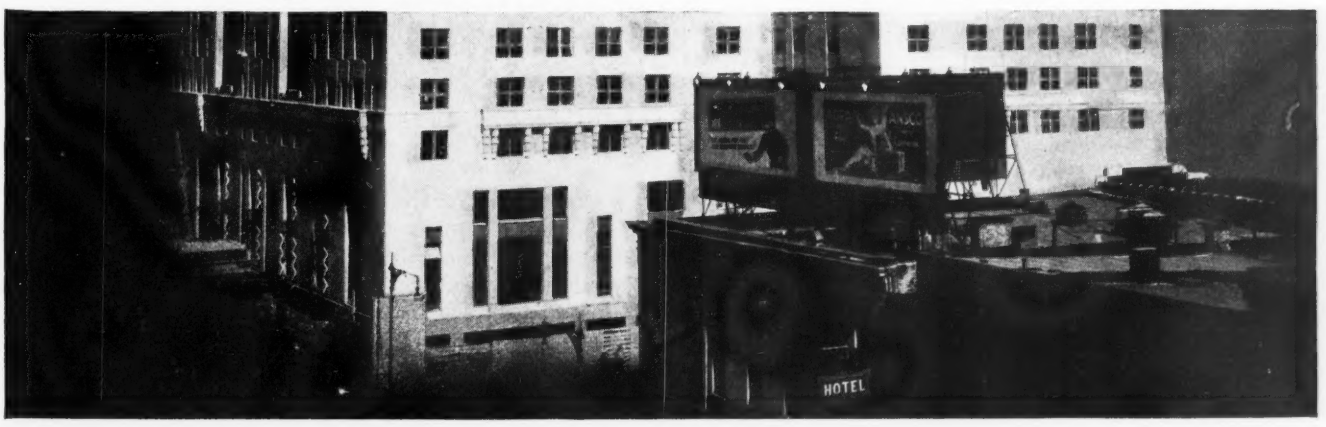
The power plant should be operated as economically as possible as a separate unit and should be credited with economies and savings over purchased steam and electricity. The engineering department should be classed as a productive unit in the hotel organization when it operates more cheaply than the utilities could supply steam and electricity. Moreover the fact should not be overlooked that a yearly saving of ten thousand dollars over purchased steam and electricity in plant operation is just as good as that much additional profit from the sale of food or rooms.

The entire operating cost of the power plant and its overhead should be "metered" to the other departments in the hotel, so that each bears its just share of the expense. After supplying all these services, why should the chief engineer be called upon to explain why the laundry uses so much water, or the kitchen so much gas, or the ballrooms so much light? With proper accounting the idea would never enter the manager's mind.

The engineering department is and should be accountable for the economical *production* of all services, but that is all. And this brings another thought: In all large central stations a corps of test engineers check operation and prevent losses. How large does an isolated plant have to be before a bright young college graduate could justify his employment by the savings he could make as special assistant to the chief engineer?

But, getting back to our "accounting," would the auditor trust the figures or use them? It does not seem to be standard practice to do it; so would it pay to go to the additional expense of installing meter equipment and of making the records later? Apparently, an accountant would have to be something of an engineer, or possibly it would be necessary to admit the engineers into the accounting department, *ex officio* or something like that.

Personally, I feel that with the proper installation of metering equipment, and with cooperation between the engineers and the auditors, there should be little need for a check by engineers of the public utility to tell the manager what is going on in his power plant. His records, with the reports received regularly from both the engineer and the auditor, should furnish a perpetual check on the engineering department.



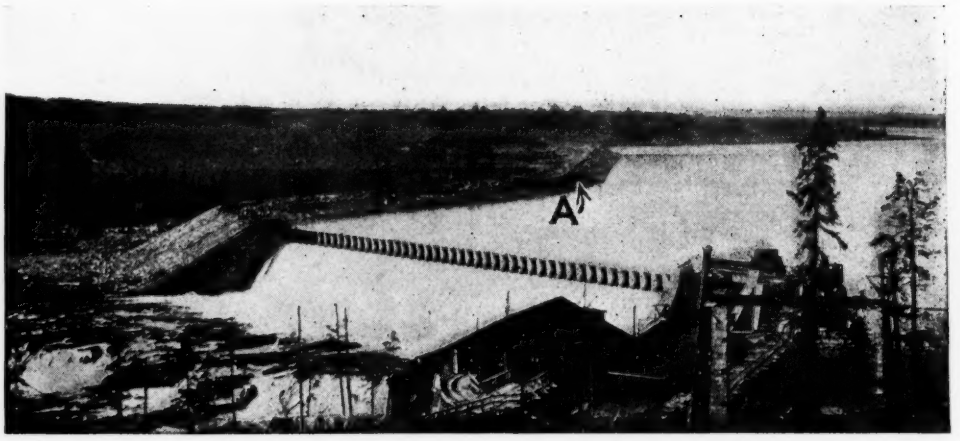


Fig. 1—The dam is 4,100 ft. long. A large part of it is of earth-and-stone construction, with two spillways

HYDRO PLANT Built Above the ARCTIC CIRCLE

By GEORGE WILLOCK
Engineer
Nydquist & Holm A.B.,
Trollhattan, Sweden

A 70,000-hp. hydro-electric plant, 29 mi. north of the Arctic Circle, where a temperature of —50 deg. F. is common, is built entirely in the rock and generates power at three different frequencies to serve a wide area in Lapland and Northern Sweden

PORJUS, the site of one of the most northerly power plants, is situated on the Lule River, 29 mi. north of the Arctic Circle, and is one in the chain of large hydro-electric plants owned and operated by the Royal Board of Water Falls of Sweden. It is the second largest hydro-electric plant in that country. This station supplies electrical energy to railways, mines and other industries in the surrounding district.

The falls at Porjus consist of a series of rapids extending a distance of 6.25 mi. from the outlet of the Great Lule Lake, the gross fall being 183.5 ft. The dam's length is 4,100 ft. in three main parts: A long earth-and-stone section running from north to south and provided with a spillway *A* 270 ft. wide, Fig. 1. The dam then turns sharply to the right to form the second part, consisting of the eastern spillway, seen in the foreground in the figure, 380 ft. wide, and the roller gate. The dam turns south again at an angle of 90 deg. to form the intake.

Fig. 2 shows the eastern spillway and the roller gate under construction. Both the eastern and western spillways provide for an overflow elevation of 1,127 ft., but they are provided with gates which allow of raising the level to elevation 1,135.

A cross-section of the roller gate is shown on the left in Fig. 4. It has two leaf plates, one below the cylinder, as is usual, and one above. The roller gate was ordered for elevation 1,129 ft., but was to be constructed so that the upper leaf plate could easily be attached for raising the water level to elevation 1,135. However, before the gate left the manufacturer, the government decided to allow raising the lake level to the higher elevation and the roller gate was then built up to its full height of 11 ft. 6 in. The cylinder is 5 ft. 3 in. in diameter and 44 ft. 4 in. long, with a free width 39 ft. 4 in. between the walls.

The upstream side of the dam, with the exception of the intake, is given a gradual slope so that ice pressing on it will be forced up toward the crest and broken. The piers, walls, crest and downstream side are protected by a stone facing anchored to the concrete foundations.

At the intake to the plant the dam is built as a solid concrete wall and is erected in a position to avoid danger from ice pressure. The upstream side is practically vertical, and at the deepest part has a height of about 50 feet.

The plant is constructed entirely in the rock, instead of bringing the water through a tunnel to a power house built on the bank below the falls. A normal winter exists eight months, exceptionally severe winters extend from August to June. When choosing the position for the power station it was found desirable, and of great importance, due to the climatic conditions, to avoid long channels or pipes above ground, which placing of the station on the river's bank would have necessitated. Corresponding calculations were made for various alternatives, and after a geological examination of the rock it was decided to build the machinery room underground and convey the water to and from the turbines through tunnels. In this way full reliability is obtained, especially during the cold winter periods. The water from the intake, which is often covered with ice 3 to 4 ft. thick, to the tailrace outlet passes entirely through tunnels in the rock, except in the distribution chamber. This chamber is roofed over as a protection against snow and cold and can be heated by warm air if necessary.

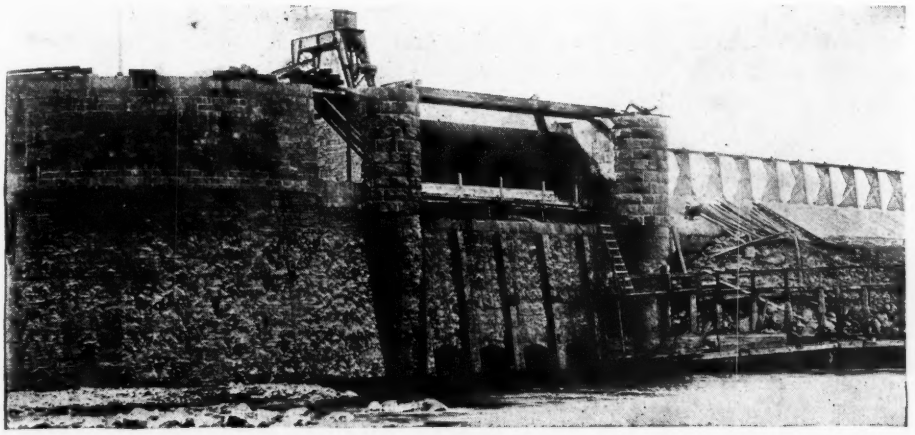


Fig. 2—Part of one of the spillways and the roller gate. The roller gate is 11 ft. 6 in. high, with a cylinder 5 ft. 3 in. in diameter x 44 ft. 4 in. long

Proof that the decision made was the right one is indicated by the fact that very little trouble is experienced from ice, in spite of the severe conditions.

Adjacent to the concrete dam is the forebay to the inlet tunnel, which forms a right angle with the dam. There are four openings, built in concrete, each 36 ft. wide x 14.75 ft. high. Two openings supply the water to the intake tunnel for the first installation, and the other two to the second. Between these openings and the intake tunnels there is an open forebay or basin, one to each tunnel. Trash racks are just behind the openings. The inlet tunnels are in solid rock and have a sectional form shown on the left, Fig. 6. Only one tunnel has been completed, the second being under construction at present. The first has a length 1,700 ft., while the second will be 2,200 ft. long. At their lower ends a section 425 ft. long is lined with concrete to prevent water from leaking into the power house.

Water leaving the tunnel enters the distribution forebay, Fig. 6, which is blasted in rock and lined with concrete. An overflow tailrace tunnel is blasted in the rock, connecting the forebay with the tailrace, so that when the water level in the forebay rises above elevation 1,135, due to a load rejection, it will spill down the overflow shaft. Equalizing chambers are provided in the inlet and tailrace tunnels and these counteract to a large extent the rise and fall in pressure due to load changes.

Water from the forebay passes through a penstock to each unit. The entrance to each penstock is closed by a gate, so that any one unit can be stopped without disturbing the others. Racks are placed behind the gates to prevent ice from entering the penstocks. The penstocks for the seven units now installed are 11.5 ft. in diameter. It is proposed to increase the penstock diameter to 14 ft. for unit No. 8. They are constructed of steel plate supported in vertical shafts blasted in the rock and embedded in concrete.

The power house is shown in the plan, Fig. 4, and in the elevation, Fig. 6 As previously mentioned, it is blasted in the rock 165 ft. below the surface. The machinery hall, as at present excavated, is 300 ft. long x 30.3 ft. wide. Along the one side are seven recesses for the turbines.

The plant at present consists of seven horizontal-shaft francis turbines and one exciter unit operating under a 174-ft. effective head. The ratings of the units are given in Table I.

TABLE I—RATINGS OF THE WATERWHEELS

Unit No.	Horsepower	Speed, R.p.m
1	14,000	225 and 250
2	12,500	225
3	12,500	225
4	12,500	225
5	15,700	250
6	15,700	250
7	18,000	250
Exciter	525	500

Cast-steel runners are used, each with 19 buckets cast in the rim and hub. The guide vanes are of the usual design. Any one can be removed without disturbing the others, and can be adjusted from the machine room.

Two water-cooled, ring-oiled, white-metal-lined bearings carry the turbine shaft. The rear bearing is of the combined journal and thrust type. They are carried in

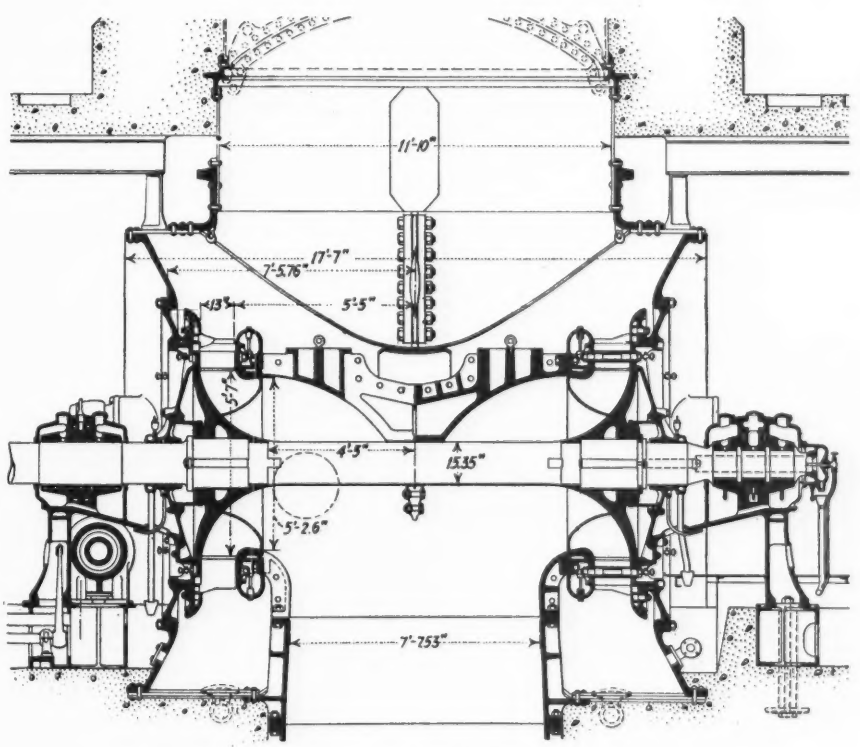


Fig. 3—Cross-section of one of the 7 turbines, which range in size from 12,500 to 18,000 horsepower

supports bolted to the turbine crownplates. These supports are fitted in machined cylindrical grooves to obtain good alignment. Between the turbine shaft and the generator there is an intermediate shaft carried by a ring-oiled, water-cooled pedestal bearing.

Automatic oil-pressure governors are installed in three main parts: the servomotor, the oil pump with pressure tank, and the governor head with the regulating valves and compensating mechanism. The servomotor is in front of the turbine, underneath the bearing and on a level with the floor. A pressure tank is placed immediately above the pump and the whole carried by a common bedplate. An oil reservoir is sunk in the floor below and immediately adjacent to one side of the oil pump. The governor head, of the combined spring-and-weight type running on knife edges, is driven by a belt from the turbine shaft.

TABLE II—RATING OF GENERATORS

Unit No.	Rating Kva.[1]	Volts	Phase	Frequency, Cycles per Sec.	Speed, R.p.m.
1	10,000	4,000	1	15	225
1	13,500	10,000	3	25	250
2	10,000	4,000	1	15	225
3	10,000	4,000	1	15	225
4	10,000	4,000	1	15	225
5	11,000	10,000	3	25	250
6	11,000	10,000	3	25	250
7	13,500	10,000	3	25	250
7	9,000	6,600	3	50	250

[1] All generators are rated on an 80 per cent power factor.

There is one exciter unit of the spiral-cased, horizontal type, with automatic oil-pressure governor. It is supplied by a separate penstock adjacent to Unit 5.

Results of the turbine tests show that they have a maximum efficiency of 92.5 per cent and an efficiency at 25 per cent load of 80 per cent, Fig. 5. The curve is unusually flat and was plotted from the test made on one of the 15,700-hp. units, but all units showed up equally favorably. Current meters in the intake to the penstock were used to measure the water. These meters were placed horizontally in a frame and moved up or down as measurements were made at the different levels. Speed variations are guaranteed not to be more than 3, 6 and 15 per cent with 25, 50 and 100 per cent load changes, respectively, and the figures obtained on test were within these limits.

The water, on leaving the draft tubes, passes through the long tailrace tunnel common to all units. There will be two tailrace tunnels, though only one has been excavated. This tunnel has the same sectional area as the inlet tunnel, 538 sq.ft., with the exception of the part between the first draft tube and a distance of about 130 ft. below No. 2 equalizing chamber. The area at the first draft tube is 538 sq.ft. and from this point it gradually increases to 1,076 sq.ft. at the fourth draft tube, thereafter gradually decreasing to 538 sq.ft. Its form is the same as the inlet tunnel shown in Fig. 6.

There are nine generators, four single-phase and five three-phase units rated as in Table II. It will be noted that the plant generates three different frequencies: 15, 25 and 50 cycles. The single-phase 15-cycle machines have a rating of 10,000 kva. at 0.8 power factor. Efficiencies at 9,400-, 6,250- and 3,100-kva. loads are 91, 93.4 and 90.1 per cent, respectively. The three-phase 25-cycles generators have a continuous output of 11,000 kva. at 0.8 power factor. Their efficiencies at 11,000- and 5,500-kva. loads are 96 and 93.5 per cent, respec-

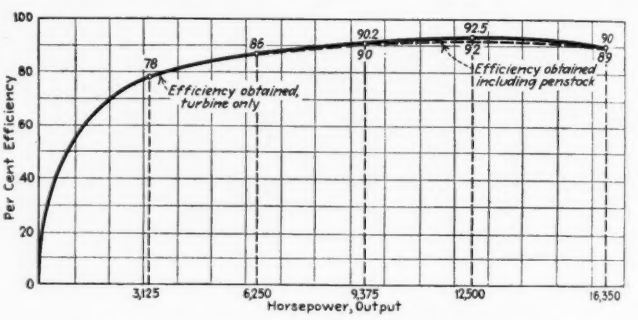


Fig. 5—Test efficiency curve from one of the turbines

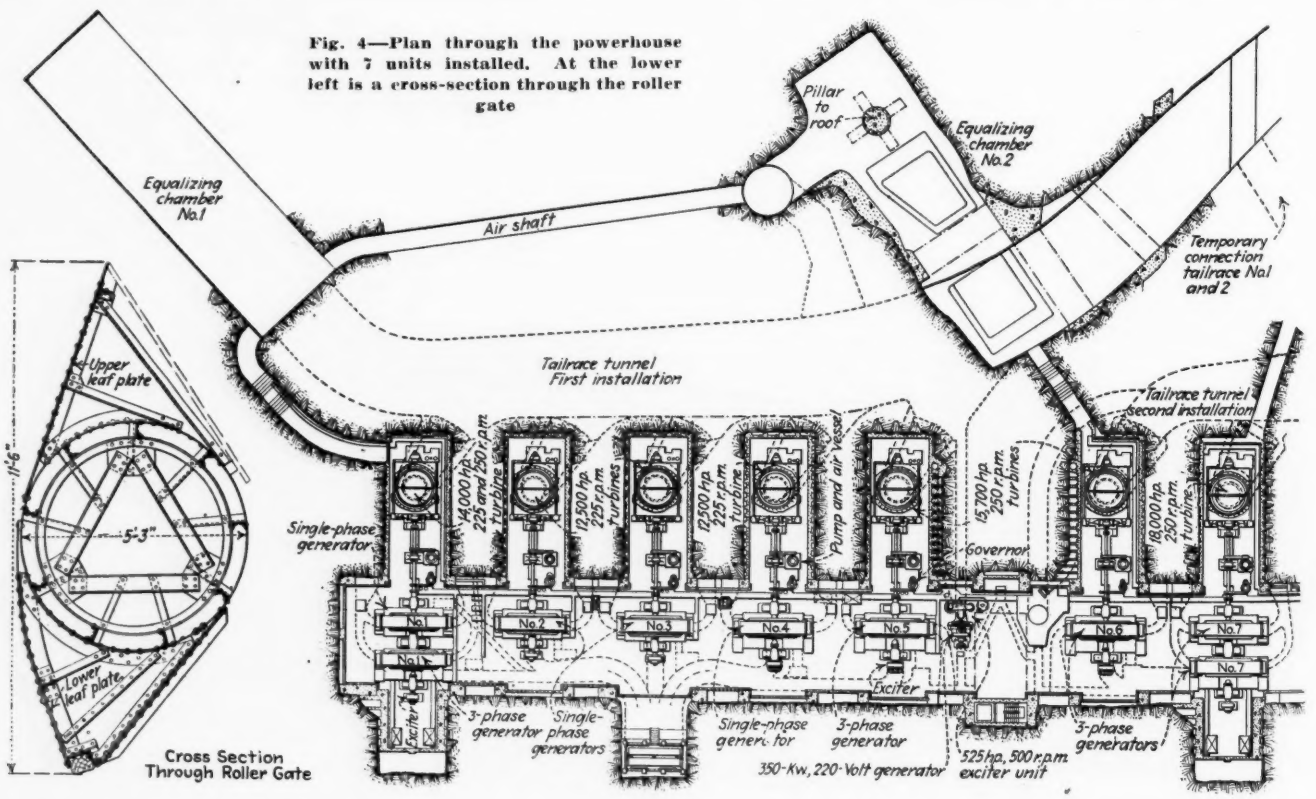


Fig. 4—Plan through the powerhouse with 7 units installed. At the lower left is a cross-section through the roller gate

tively. At 8,800-kva. load and unity power factor the efficiency is 96.5 per cent.

The instrument building is the only part of the power house visible above ground. It contains the transformers and all other electrical equipment for both the single- and three-phase systems, pumping chambers, conrol room, offices and workshops. Three shafts connect the instrument room with the machinery hall. The largest of these, 430 sq.ft. area, is used for hoisting and lowering equipment from and into the plant. There is a shaft containing the passenger elevator and another for the cables from the generators. Above the hoisting shaft is a traveling crane with a lifting capacity of 50 tons; the height of the lift is 187 feet.

There are seven transformer banks, four single-phase, each 10,000-kva. capacity, 4,000 volts primary and 80,000 volts secondary, two three-phase transformer banks are each rated 13,500 kva. 10,000 to 70,000 volts 25 cycles; and one 3,000 kva. 6,600 to 50,000 volts 50 cycles. The transformers are water-cooled, oil-insulated and totally inclosed, and are provided with distance thermometers so that the temperature can be read in the control room.

Transmission lines cover a large part of Lapland, and extend south 320 miles. Apart from the single-phase transmission lines for the Riksgransen Railway, there are 90 miles of lines for the three-phase 70,000-volt and 216 miles for the three-phase 50,000-volt power.

Notwithstanding the severe climatic conditions this plant has operated satisfactorily. The design, the results of careful investigation, gives credit to the engineers of the Royal Board of Water Falls.

The principal contractors for the power house equipment were: Roller gate, turbines and governor equipment; Nydquist & Holm A.B., Trollhattan; all generators, three-phase transformers, switchboard equipment and transmission-line material, Allmänna Svenska Elektriska Aktiebolaget, Västeras; single-phase transformers, Luth & Rosens Elektriska A. B., Stockholm—all firms in Sweden. The transmission lines were built by the Royal Board of Water Falls.

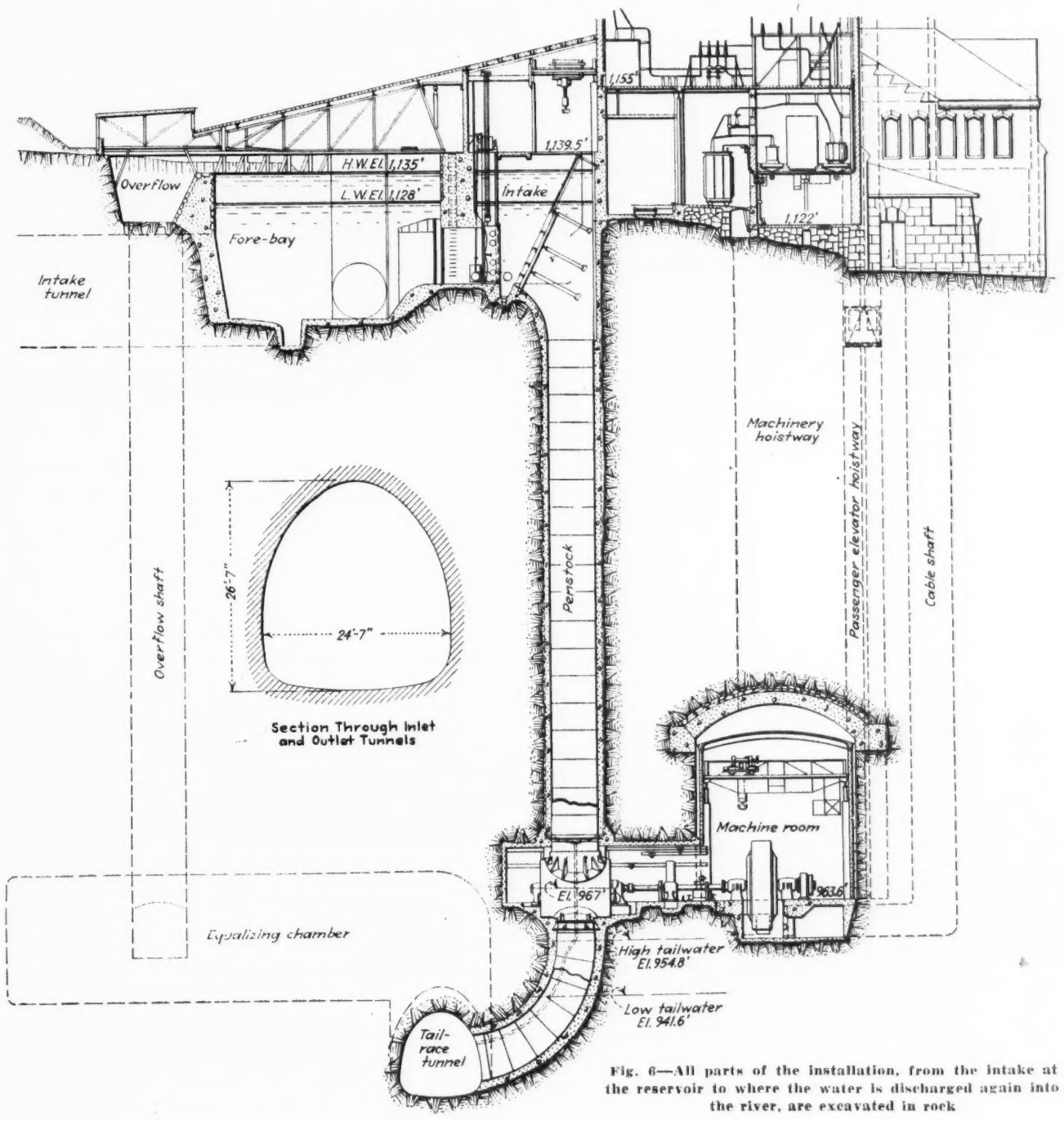
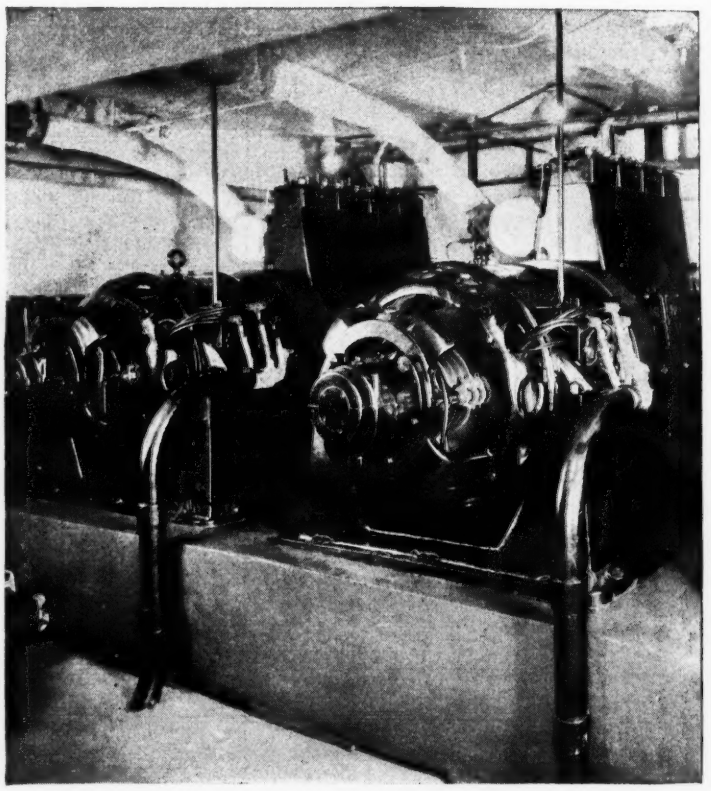


Fig. 6—All parts of the installation, from the intake at the reservoir to where the water is discharged again into the river, are excavated in rock

First Multiple-Unit Diesel Power Plant With



HIGH COST of continuous attendance has hindered the use of diesel engines in plants smaller than about 500 kw. delivering 24-hr. service, as in city buildings. Three shifts are needed, but during two of them the load is so light that the payroll offsets the good economy of the diesel.

High attendance costs can, however, be overcome by automatic control, and two factors have now combined to make possible the completely automatic operation of diesel plants. One is the development of a system of automatic control of a multiple-unit plant which fulfills certain essential requirements, namely: (1) Units must be started and stopped one by one in accordance with the line load. (2) The engine supply services must be thoroughly safeguarded. (3) In case of trouble with any unit it should be shut down, and another put in service. (4) Perfect voltage regulation must be maintained under all conditions, including load surges, starting operations, or difficulties.

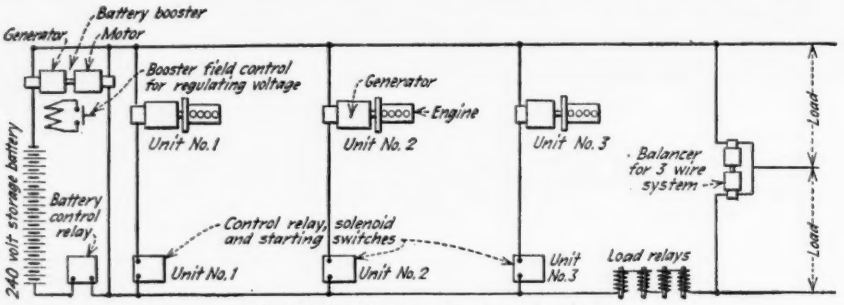
The other factor is the refinement of diesels themselves, whereby they are now not only highly efficient but fully reliable for continuous service under automatic control. In the automatic system occasional supervision is necessary, but the time required is small.

A fully-automatic diesel plant of this type has been installed in the Hotel Chelsea, New York. Three 50-kv. diesel generating units, a 240-volt storage battery, a battery booster, a 240-120 volt balancer, and an automatic switchboard are contained in an interior basement room 22 ft. square with 8 ft. 7 in. headroom.

Starting and stopping is by adjustable-load relays normally set to keep the load on each engine between 40 and 90 per cent of rating. Thus, in this three-unit plant, loads less than 20 kw. are carried by the storage battery. When the load increases to 20 kw. (or when the storage battery has discharged to a predetermined point), the first unit is started by motorizing its generator with current from the battery. It immediately takes over the entire load and also recharges the battery, thus operating at something more than 40 per cent capacity. The first engine carries the load up to 45 kw., when the second is started by its load relay and divides the load with the other, so that each runs at 45 per cent of rating. The two units serve the load until it increases to 90 kw., when the third goes on, reducing the load per unit to 30 kw., or 60 per cent of rating. Load increases during the engine starting periods are carried by the battery.

Continuity of service is well safeguarded. The fuel, lubricating oil and cooling water are arranged for maximum reliability. However, if one of these should fail, the engine fuel pumps are shut off, the engine is disconnected from the bus, and another unit is immediately put into service. At the same time an alarm is transmitted to the supervising office and a maintenance man is sent to correct the trouble. Meanwhile, the full power service is maintained by the running engines, supplemented by the storage battery. The latter has sufficient capacity to carry the entire load for a time. Similar protection is afforded if a unit should fail to start when required; if it does not come on the line within one minute after starting current has been applied, it is automatically disconnected from the bus, another unit is started and an alarm is transmitted.

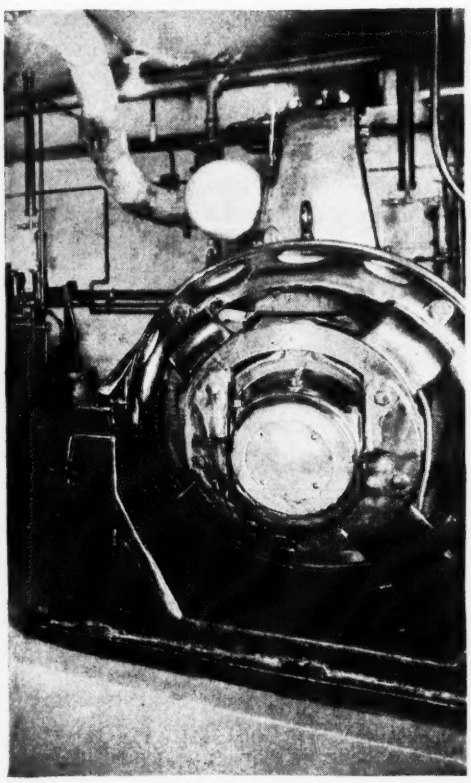
Exceedingly close voltage regulation, with complete absence of flicker in lights, is vital to service such as is



Simplified diagram of power circuits

Full Automatic Control

By EDGAR J. KATES
Consulting Engineer, New York



Loads from 20 to 45 kw. are carried by one unit. Then the second starts automatically. The third engine starts when the load reaches 90 kw.

View of complete switchboard, with storage battery in the background

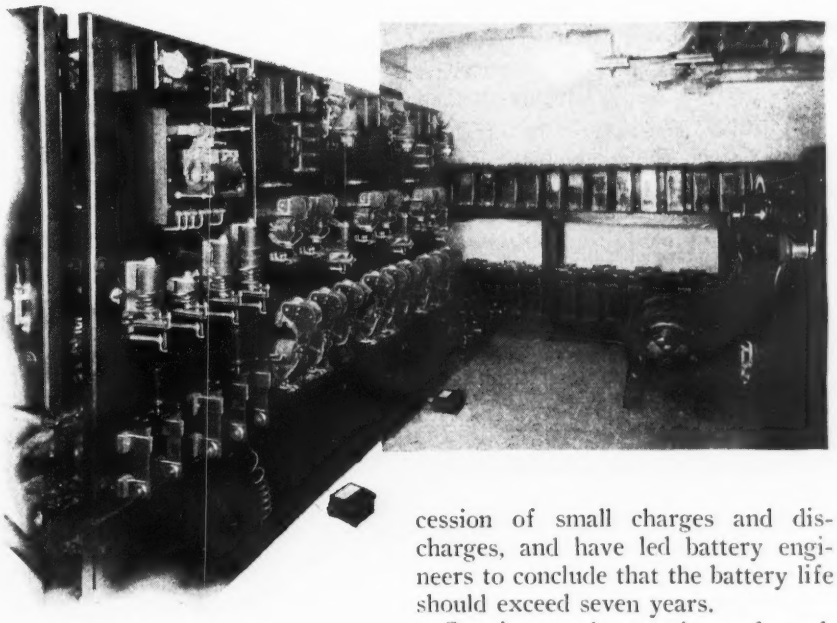
required in hotels and office buildings. In the ordinary small power plant serving a fluctuating load, a flicker will generally be perceived whenever a sudden load surge occurs, such as when an elevator is started. This is completely absent with the control used in the Hotel Chelsea plant. Close voltage regulation is accomplished by connecting the storage battery to the bus through a battery booster with sensitive field control. The power circuit is shown on page 990. Whenever a sudden load is put on the plant the booster voltage is at once increased, thus causing the battery to deliver to the bus all of the additional current required to maintain full voltage on the line. Thus the energy increment is drawn from the storage battery and not from the engines, and the battery voltage is simultaneously boosted. This prevents the flicker that would occur if the surge were thrown directly on the generating units or if it were taken by a storage battery floating on the line without a controlled booster. The load is particularly severe; there is not only the usual elevators, but also a laundry containing large reversing motors. Yet no flicker is noticeable.

Whenever surplus generating energy is available, as when the load falls off suddenly, the normal polarity of the battery booster is reversed, causing the surplus energy to be absorbed by the battery instead of momentarily raising the line voltage.

If the load change is of short duration, it is handled by the battery. The unnecessary starting of additional generating units because of momentary surges is prevented by a dashpot attached to the starting solenoid. The dashpot causes a time lag of about five seconds from the time the load relay closes until the first starting contact is made. Thus short-time surges are taken care of by the battery, whereas a heavy and sustained load increase causes the starting of an additional unit.

It is evident, therefore, that the storage battery performs several important functions, namely: It supplies energy for starting the diesels, provides a reservoir of quickly controlled energy to supply sudden current demands without loss of voltage, and provides an emergency reserve of power.

The battery service requirements are not severe, as it is never called upon to take a long discharge except in emergency. Graphic records of the energy interchange between battery and bus show a continuous succession of small charges and discharges, and have led battery engineers to conclude that the battery life should exceed seven years.



Starting and stopping of each engine is controlled by a pair of solenoids acting on the fuel pump regulating linkage. When the solenoids are dead the fuel pump bypass valves are held wide open, preventing delivery of fuel to the injection nozzles. When the main solenoid is energized, the bypass valves are permitted to close partly, causing the pump to deliver about half-load fuel. Subsequently the secondary solenoid is energized, which completely releases the fuel pump to

governor control. When the unit is delivering power to the line its fuel pump is not interfered with by the electrical controls, and it is governed at constant speed by the regular engine governor. When a unit is to be shut down, the solenoids are deenergized, which opens the fuel pump bypass valves. The solenoids are provided with contacts connected to resistance shunts for reducing the current consumption after the solenoids have acted. Balancing of the load among the operating units is accomplished by the compound fields of the generators and the equalizer connections. If any unit is not taking its share of the load its output voltage increases, causing it to take on more load until it is doing the same as the other units. An incoming generator immediately takes its share of the load as soon as it is connected to the bus. The sequence of events when a unit is started is as follows:

1. Increase in load closes the line load relay, energizing the starting contactor solenoid, which closes a set of contacts successively.
2. The first contact energizes the first starting switch. This supplies current to the generator through a resistance grid, causing the generator to revolve as a motor.
3. The next contact energizes the second starting switch, which reduces the resistance in the starting circuit and increases the motoring speed.
4. The main fuel pump solenoid is then energized, causing the fuel pump to deliver part-load fuel to the injectors. The engine then fires, and accelerates smoothly to normal speed.
5. When the voltage of the incoming generator equals that of the bus the main switch and equalizer switch are closed, and simultaneously the secondary solenoid on the fuel pump is energized, releasing the fuel pump completely to control of the engine governor.
6. The incoming unit takes its share of the load.

The time consumed from the closing of the first starting switch to the taking of load by the incoming unit is a matter of only ten seconds.

Diesel Plant Details

There are three 4-cylinder, two-stroke-cycle, 500-r.p.m. engines each directly connected to a 50-kw. single-bearing special compound-wound generator. The three units are on a common foundation of reinforced concrete 18 in. thick which rests on six natural cork strips 20 in. wide x 3 in. thick laid upon the floor. No excavation was made for the foundation. This construction has been successful in preventing the transmission of vibration.

The fuel storage tank, in a section of the coal pocket, is of 1,500 gal. capacity. A distant-reading float gage on the engine room wall shows the quantity of oil in the tank. Separate fuel suction lines run from the tank to each engine, which has its own direct-driven fuel supply pump delivering into a standpipe on the engine. Surplus oil overflows from the several standpipes to a common return line to the tank. In case of failure of any supply pump surplus oil from the others will supply the affected engine.

The engines exhaust through flexible pipes connected to an insulated header which also serves as expansion tank and muffler. The exhaust then passes through a second muffler to the base of the boiler stack, ending in an elbow pointing upward. An automatic valve in the exhaust line of each engine closes when the engine stops, and prevents the exhaust of running engines passing back to the idle unit. The exhaust piping is flexibly suspended, and there is no transmission of sound or vibration.

Two sources of engine cooling water are provided. Ordinarily the water is taken direct from the city mains, but if the pressure should be shut off a secondary supply is automatically fed in from the roof tank. Jacket-water discharge temperatures are maintained constant by thermostatic valves. A large part of the warmed water is recirculated through the engines without being cooled. This produces a vigorous flow through the jackets with a minimum supply from the mains, it reduces temperature differences in the jackets and facilitates quick action of the thermostats. Arrangements are being made to utilize the discharged hot water for hotel service.

Lubrication is by a pressure system using individual direct-driven pumps. If the pressure should fail on any engine, a pressure bellows opens a contact in the solenoid circuit on the fuel pump, thus bypassing the fuel and stopping the engine.

Performance

The plant has been in continuous 24-hr. service since November, 1930, and has fully demonstrated its smooth functioning and reliability. At present one mechanic is employed, but his services will be distributed among several other plants about to be built.

The excellent fuel economy testifies to the favorable operating conditions. Despite the exceedingly rough load in the daytime and the very light load at night,

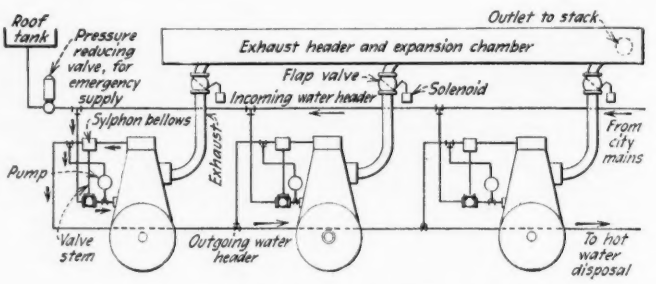
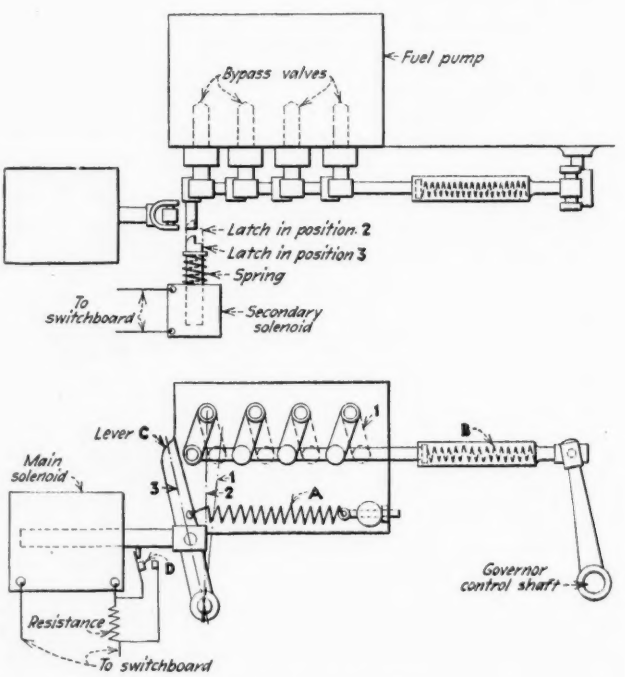


Diagram of jacket water and exhaust systems



FUEL PUMP CONTROL

Position 1—Engine stopped. Both solenoids dead. Spring *A* overcomes spring *B*; lever *C* pushes regulating linkage into Position 1, holding pump bypass valves open. *Position 2*—Engine starting. Main solenoid alive, secondary solenoid dead. Lever *C* in Position 3. Latch in Position 2 allows spring *B* to push regulating linkage into Position 2, partly closing bypass valves and causing delivery of half-load fuel. Contacts *D* open, putting resistance in circuit of main solenoid. *Position 3*—Engine on line. Both solenoids alive. Lever *C* and latch both in Position 3, releasing bypass valves to control of engine governor.

these small two-stroke-cycle engines produced an average of 10.66 kw.-hr. per gallon of fuel during the nine week period from March 14 to May 16. These figures are *net* output of the plant and include all auxiliary losses on account of the storage battery, booster unit, balancer set, switchboard controls and ventilating fans. The lubricating oil consumption averages about one gallon per 2,050 rated horsepower-hours.

Because of the low costs for fuel, lubrication and attendance, over-all cost of power has proved much less than that previously purchased.

The automatic control system is based upon the patents of C. F. Strong, and the plant was designed and installed by Mr. Strong with the assistance of the writer.

Refrigeration Problems Solved Without Involved Calculations

By JOHN E. STARR
Consulting Engineer

MANY ENGINEERS confronted with the problem of calculating compressor size and input per ton of refrigeration proceed to plod through an involved mathematical process, when a simple and more accurate method is available, namely, the careful and elaborate tables prepared by the United States Bureau of Standards.

In these tables are covered about all the conditions met with in ordinary, and even extraordinary, practice. All the calculations have been made and the results so set down that anyone having a common school education and who knows enough mathematics to add, subtract and divide can solve accurately the most abstruse problems in the thermodynamics of the ammonia cycle.

He has only to know that 778 ft.-lb. equal 1 B.t.u., and that 33,000 ft.-lb per minute equals 1 hp. So complete are the tables that most of the interpolations necessary to suit a particular case can be made mentally; if great accuracy is desired it is only necessary to use a piece of square ruled paper, preferably with 0.1 in. divisions, and construct a curve from the data given.

It is an almost daily task of the engineer to find the horsepower required per ton of refrigeration. He can very quickly find the ideal horsepower per pound of ammonia calculated from the tables. And by multiplying this value by the number of pounds of ammonia required per ton he has the horsepower per ton with ideal, or adiabatic, compression, and has only to apply the usual volumetric efficiencies to get at the probable actual horsepower per ton. Or he may check the ideal against the actual horsepower to learn the volumetric performance of the system.

The entropy for back pressures are given, each back pressure from 5 to 40 deg. absolute at one-pound intervals and from 40 to 70 at two-pound intervals, including all likely superheats. Entropy at all head pressures from 80 lb. to 300 lb. is also given, with superheats. Because the relation of entropy and superheat plots in nearly a straight line, it is easy to interpolate if great exactness is required, although it is also easy to estimate from the nearest figure in the table.

No attempt will be made to explain entropy. For the engineer using ammonia tables it is sufficient to know that

BUREAU OF STANDARDS TABLES OF THE PROPERTIES OF AMMONIA
SATURATED AMMONIA—TEMPERATURE TABLE—Continued

Temp. Fahr.	Pres. Lbs. per Sq. In.	Spec. Vol. Cu. Ft. per Lb.		Total Heat of Liquid	Latent Heat of Evap.	Total Heat of Vapor	Entropy		
		Liquid	Vapor				Liquid	Evap.	Vapor
−10	23.75	.02393	11.50	32.1	576.1	608.2	.074	1.281	1.355
− 9	24.35	.02396	11.23	33.2	575.4	608.6	.076	1.277	1.353
− 8	24.98	.02399	10.97	34.3	574.6	608.9	.078	1.272	1.350
− 7	25.61	.02401	10.71	35.3	573.9	609.2	.081	1.268	1.349
− 6	26.26	.02404	10.46	36.4	573.2	609.6	.083	1.264	1.347
− 5	26.92	.02406	10.22	37.5	572.4	609.9	.086	1.259	1.345
− 4	27.59	.02409	9.99	38.6	571.7	610.3	.088	1.255	1.343
− 3	28.28	.02411	9.76	39.7	570.9	610.6	.090	1.250	1.340
− 2	28.98	.02414	9.54	40.7	570.2	610.9	.093	1.246	1.339
− 1	29.69	.02417	9.32	41.8	569.4	611.2	.095	1.242	1.337
0	30.42	0.02419	9.114	42.9	568.7	611.6	0.097	1.237	1.334
1	31.16	.02422	8.911	44.0	567.9	611.9	.100	1.233	1.333
2	31.92	.02424	8.712	45.1	567.2	612.3	.102	1.229	1.331
3	32.69	.02427	8.520	46.2	566.4	612.6	.104	1.224	1.328
4	33.48	.02430	8.332	47.2	565.7	612.9	.107	1.220	1.327
5	34.28	.02432	8.149	48.3	564.9	613.2	.109	1.216	1.325
6	35.09	.02435	7.971	49.4	564.1	613.5	.112	1.212	1.324
7	35.92	.02438	7.797	50.5	563.3	613.8	.114	1.207	1.321
8	36.77	.02440	7.628	51.6	562.6	614.2	.116	1.203	1.319
9	37.63	.02443	7.464	52.7	561.8	614.5	.119	1.199	1.318
10	38.51	.02446	7.304	53.8	561.0	614.8	.121	1.195	1.316
11	39.40	.02449	7.148	54.9	560.2	615.1	.123	1.191	1.314
12	40.31	.02451	6 996	56.0	559.5	615.5	.125	1.186	1.311
13	41.24	.02454	6 847	57.0	558.7	615.7	.128	1.182	1.310
14	42.19	.02457	6.703	58.1	557.9	616.0	.130	1.178	1.308
70	128.8	.02632	2.314	120.5	508.9	629.4	.254	.961	1.215
71	131.1	.02635	2.275	121.7	508.0	629.7	.256	.957	1.213
72	133.4	.02639	2.236	122.8	507.0	629.8	.258	.954	1.212
73	135.7	.02643	2.199	123.9	506.0	629.9	.260	.950	1.210
74	138.1	.02646	2.162	125.1	505.0	630.1	.262	.946	1.208
75	140.5	.02650	2.126	126.2	504.1	630.3	.264	.943	1.207
76	143.0	.02653	2.091	127.4	503.1	630.5	.266	.939	1.205
77	145.4	.02657	2.056	128.5	502.1	630.6	.268	.936	1.204
78	147.9	.02661	2.022	129.7	501.1	630.8	.271	.932	1.203
79	150.5	.02664	1.989	130.8	500.1	630.9	.273	.929	1.202
80	153.1	.02668	1.956	132.0	499.1	631.1	.275	.925	1.200
81	155.7	.02672	1.924	133.1	498.1	631.2	.277	.921	1.198
82	158.3	.02675	1.893	134.3	497.0	631.3	.279	.918	1.197
83	161.0	.02679	1.862	135.4	496.0	631.4	.281	.914	1.195
84	163.7	.02684	1.832	136.6	495.0	631.6	.283	.911	1.194
85	166.4	.02687	1.803	137.7	494 0	631.7	.285	.907	1.192
86	169.2	.02691	1.774	138.9	493.0	631.9	.287	.904	1.191
87	172.0	.02695	1.745	140.0	491.9	631.9	.289	.900	1.189
88	174.8	.02699	1.717	141.2	490.9	632.1	.292	.896	1.188
89	177.7	.02703	1.690	142.3	489.8	632.1	.294	.893	1.187

Fig. 1—Part of the tables on properties of ammonia

entropy is a property of ammonia and other fluids that remains constant during an ideal, or adiabatic, compression, during which process no heat is lost through the cylinder wall. In the ammonia tables the entropy is given for the liquid, for the vaporization and for the superheat. In the ideal cycle the suction vapor is dry saturated, that is, all the fluid has been evaporated into vapor but no superheat has been added. The entropy of the vapor at the suction pressure is given in the ammonia tables. At 5 deg. F. the suction pressure is 34.28 lb. abs. if the vapor is dry saturated, and from Table I (a part of the ammonia tables) the entropy of the vapor is found to be 1.325 and the total heat in the vapor to be 613.2 B.t.u. During ideal, or adiabatic, compression no heat is lost through the cylinder walls; consequently the entropy remains constant during compression. Suppose the discharge pressure is 170 lb. abs. (155 lb. gage); to ascertain the heat in each pound of ammonia at discharge it is only necessary to find the condition of the compressed vapor at which the entropy is the same as the entropy of the suction gas. As shown in Fig. 2, an entropy of 1.325 at 170 lb. abs. corresponds to a discharge temperature a trifle over 210 deg. F., and the total heat H at this condition is 713 B.t.u. As any increase in the heat of the gas is that due to the work of compression, the heat equivalent of this work is obviously the difference of the total heat of the vapor at the suction pressure (613.2 B.t.u. for 5 deg. F. and 34.28 lb. vapor) and the total heat H at the discharge (713 B.t.u. for 170 lb. and 200 deg. vapor). This difference, 713 — 613.2

= 100 B.t.u., is the work of compression per pound of ammonia handled.

In the condenser the vapor is cooled and the latent heat of vaporization recovered to obtain condensation of the fluid. The liquid leaving the condenser contains the heat of the liquid at the condenser pressure. This is given in the ammonia tables for various pressures, as shown in Fig. 1. For 169.2 lb. abs. which is approximately 170 lb. abs., the heat of the liquid is 138.9 B.t.u.

In the coil the ammonia evaporates and each pound of dry saturated ammonia will contain the heat given under the heading *total heat of vapor* in the tables. For 34.25 lb. abs. pressure this is found, Fig. 1, to be 613.2 B.t.u. The difference between the heat the liquid holds entering the coils and what it contains leaving the coils is the refrigeration done by one pound of ammonia. In the example it is 613.2 — 138.9 = 474.3 B.t.u. As a duty of one ton of refrigeration is the removal of 200 heat units per minute, the pounds of ammonia to be circulated per minute per ton of refrigeration is 200 divided by the difference between the liquid heat at the condenser pressure and the heat of the vapor and the coil pressure. In the example it is $\frac{200}{613.2 - 138.9} = 0.421 +$ lb. of ammonia per minute. The work of compression per pound of ammonia has been found to be 100 B.t.u. The heat per ton of refrigeration is then the work per pound times the pounds circulated per minute, or, in the example, $100 \times 0.421 = 42.1$ B.t.u.

As has been stated, 1 hp. is equivalent to 42.42 B.t.u. per minute, so the ideal compression horsepower in the example will be $42.1 \div 42.42 = 0.99 +$, or almost 1 horsepower.

So with a very slight knowledge of thermodynamics and an elementary knowledge of arithmetic one can arrive at the basis required in the perfect performance of a machine that neither gains nor loses heat during compression. All the calculation involving the use of higher mathematics has been done. Why not accept and use the printed results instead of wading through a lot of calculations?

Having arrived easily, quickly and accurately at the theoretical horsepower needed by the compressor, what of the practical? Experience teaches that an actual compressor cannot attain more than from 75 to 85 per cent of the theoretical. How near is it possible to come? In other words, what is the volumetric efficiency of a compressor?

The total volumetric efficiency depends upon too many variables to render it possible to make a hard and fast formula that will fit all speeds and sizes of compressors. Even in a compressor fitted with the smallest amount of clearance possible, there is still some leakage. There is a leakage of gas in the minute crack between the piston and cylinder which will vary with the size of the machine and its speed. In the smaller sizes experiments have shown that leakage is a large item. No basic formula can take these variants into consideration. The heat transfer from the wall of the cylinder to the incoming gas is very complicated.

Therefore it is perhaps best to rely on an empirical formula based on best average practice. Volumetric efficiency $= 1 - (t_1 - t_o)$, in which t_1 is the theoretical temperature of the discharge gas, which value is obtainable from the tables of ammonia properties, and t_o the observed temperature after compression.

One may be certain that if he calculates the adiabatic horsepower from the tables as indicated and corrects this horsepower by the volumetric efficiency, he will have the actual horsepower, and if he adds for transmission losses according to the size of the machine he will have the actual horsepower the compressor requires. Transmission and friction losses vary from 17½ to 20 per cent, depending upon the size and design of the equipment; if any existing compressor does not substantially operate within the limits so deduced it is time to overhaul the valves for leakage or perhaps to rebore the cylinder.

None of the values of volumetric efficiency and transmission applies to very small, or fractional-tonnage, machines. In the 125-to-150 lb. machines the leak of gas past the piston is such a large item that it upsets the approximation of volumetric efficiency given, and the percentage of transmission loss is also much greater; so the small machine must be considered in a class by itself.

Temp. °F.	Abs. Pressure 170 lb./in.² Gage Pressure 155.3 lb./in.² (Sat'n. Temp. 86.29° F.)			Abs. Pressure 175 lb./in.² Gage Pressure 160.3 lb./in.² (Sat'n. Temp. 88.06° F.)		
t	*V*	*H*	*S*	*V*	*H*	*S*
(at sat'n)	(1.764)	(631.6)	(1.1900)	(1.716)	(631.8)	(1.1874)
90	1.784	634.4	1.1952	1.725	633.3	1.1902
100	1.837	641.9	1.2087	1.777	640.9	1.2039
110	1.889	649.1	1.2215	1.828	648.2	1.2169
120	1.939	656.1	1.2336	1.877	655.2	1.2291
130	1.988	662.8	1.2452	1.924	662.1	1.2408
140	2.035	669.4	1.2563	1.971	668.7	1.2520
150	2.081	675.9	1.2669	2.016	675.2	1.2628
160	2.127	682.3	1.2773	2.061	681.6	1.2732
170	2.172	688.5	1.2873	2.105	687.9	1.2833
180	2.216	694.7	1.2971	2.148	694.1	1.2931
190	2.260	700.8	1.3066	2.191	700.3	1.3026
200	2.303	706.9	1.3159	2.233	706.4	1.3120
210	2.346	713.0	1.3249	2.275	712.5	1.3211
220	2.389	719.0	1.3338	2.317	718.5	1.3300
230	2.431	724.9	1.3426	2.358	724.5	1.3388
240	2.473	730.9	1.3512	2.398	730.5	1.3474
250	2.514	736.8	1.3596	2.439	736.4	1.3558
260	2.555	742.8	1.3679	2.479	742.4	1.3642
270	2.596	748.7	1.3761	2.519	748.3	1.3724
280	2.637	754.6	1.3841	2.558	754.3	1.3804
290	2.678	760.5	1.3921	2.598	760.2	1.3884
300	2.718	766.4	1.3999	2.637	766.1	1.3963
310	2.758	772.3	1.4076	2.677	772.0	1.4040
320	2.798	778.3	1.4153	2.716	778.0	1.4117
330	2.838	784.2	1.4228	2.754	783.9	1.4192
340	2.878	790.1	1.4303	2.793	789.9	1.4267
350	2.918	796.2	1.4377	2.832	795.9	1.4341
360	2.957	802.0	1.4450	2.870	801.8	1.4464
370	2.997	808.0	1.4522	2.909	807.8	1.4486
380	3.036	814.0	1.4594	2.947	813.8	1.4558
390	3.075	820.0	1.4665	2.985	819.7	1.4629
400	3.114	826.0	1.4735	3.023	825.7	1.4700

Fig. 2—Properties of ammonia vapor at 170 lb. abs. pressure, in which *t* is the total temperature, *V* the volume in cubic feet per pound, *H* the total heat and *S* the entropy

Automatic Boiler Control As a Safety Factor

By W. H. MONAHAN
Engineer
H. A. Brassert & Company, Chicago

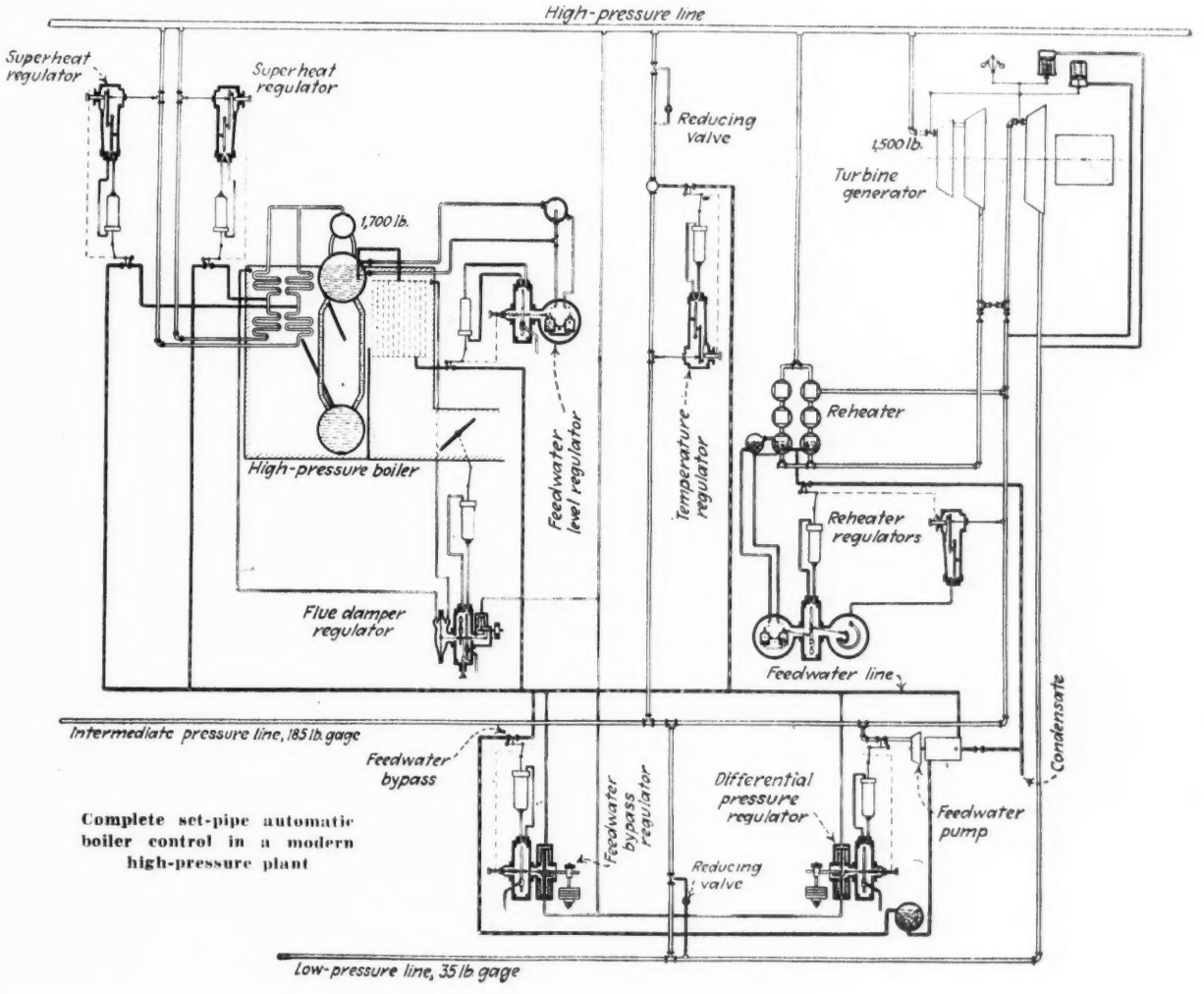
AUTOMATIC REGULATION in steam power plants is installed mainly to control production and to increase efficiency. Just how far the safety of the plant is increased by installing automatic regulation was proved recently by the unexpected shutting down of a turbine in the Ilse Bergbau A.G., Berlin, Germany, three-pressure plant, operating at 1,700 lb. boiler pressure. Steam extracted between stages of the turbine-generator may pass to a reheater or to an intermediate-pressure header. The turbine exhausts to a low-pressure header. To the latter two headers the steam supply also may come through reducing valves, as explained by an article in the Oct. 21, 1930, number of *Power*.

Steam generation in this plant is controlled by automatic jet-pipe regulation that provides instantaneous action in case of changes in volume, pressure and temperature. Recently when the high-pressure turbine failed, owing to an accidental closing of the emergency valve, the boiler pressure immediately exceeded the set value. The flue dampers of both boilers, governed automatically by the same pressure, closed quickly, so that the boiler safety valves were not required to release. At the same time a pressure drop of about 3 to 4 per cent occurred in the intermediate-pressure and low-pressure headers. As a result the reducing valves between the three steam lines opened, and the balance on the system was restored.

Below the high-pressure reducing valve a desuperheater with automatic temperature control brought the steam, already expanded to intermediate pressure, to the desired temperature within a few seconds. As soon as the two pressure-reducing valves functioned the boiler pressure came back to normal and the flue dampers opened again to restore normal conditions.

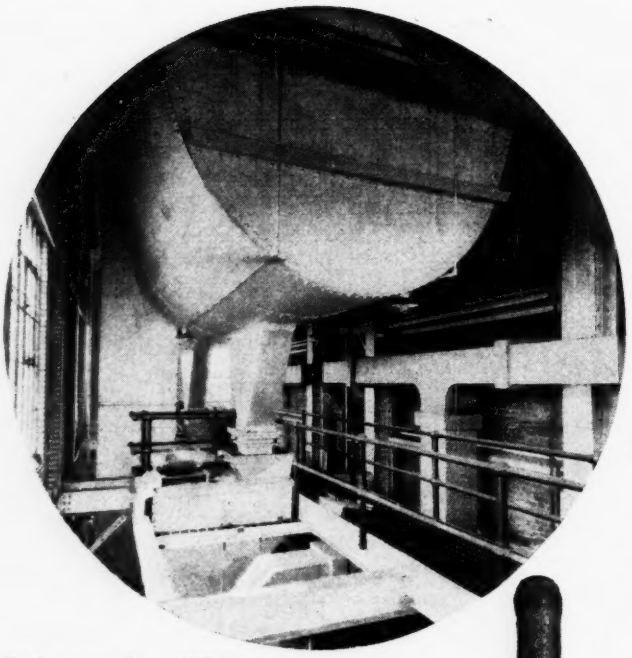
In the meantime the boiler-feed pump governor increased the feed pressure to maintain a constant differential between water and steam pressure, so that an automatic bypass opened into the surge tank, thus relieving the high-pressure feed line. The action lasted only a few seconds. The relief through the bypass valve took place without any noise, even with a pressure difference of about 1,740 pounds.

Without the foregoing extensive automatic control it would not have been possible to maintain the steam delivery to the consumers on the intermediate-pressure and low-pressure systems without interruption. Furthermore, the instantaneous and exact adjustment of pressures and temperatures tended to prevent serious damage to the boiler plant and to the operating personnel. Finally, the fact that no steam was wasted through the safety valves represents a gain from the viewpoint of thermal efficiency.



Complete set-pipe automatic boiler control in a modern high-pressure plant

Modern Steam Plant SERVES B. & A. ROUNDHOUSE



Coal passes from 150-ton suspended bunker to coal scales before delivery to unit pulverizers

STEAM PLANTS to serve engine terminals—"roundhouses"—are typically old, dirty and inefficient. Not so the Boston & Albany installation at its Beacon Park engine terminal, four miles from Boston, Mass. Here is a new plant (replacing one that was obsolete) notably clean, light and airy, and equipped for highly efficient operation.

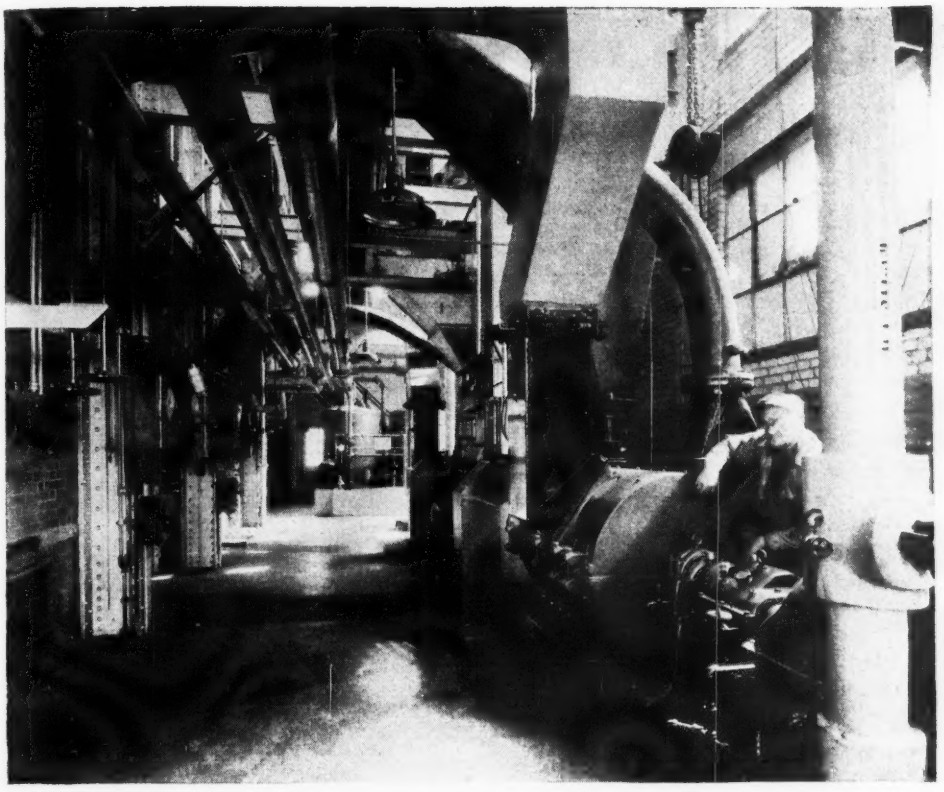
The two 4,450-sq.ft. Stirling-type water-tube boilers at Beacon Park are fired by paddle-type unit pulverizers, fed in turn through coal scales from suspended overhead bunkers. Boilers were designed for 250 per cent rating and 180 lb. pressure. Natural draft, with turbulent-type burners, is used.

Other equipment includes vacuum ash conveyor, deaërating feed-water heater, zeolite water treatment, continuous blowdown with heat exchanger, CO_2 recorders and steam-flow meters.

The 10-in. main steam header has electrically welded joints. Outside lines (8-in. steam, 6-in. exhaust and 4-in. compressed air) are supported on structural steel towers.

A two-stage steam-driven air compressor of 1,734 cu.ft. free air per minute capacity (110 lb. pressure) has been installed. Electric power is purchased, but an

The plant supplies steam and compressed air to two engine houses, totalling 55 stalls. Features include: pulverized coal, continuous blowoff, welded piping



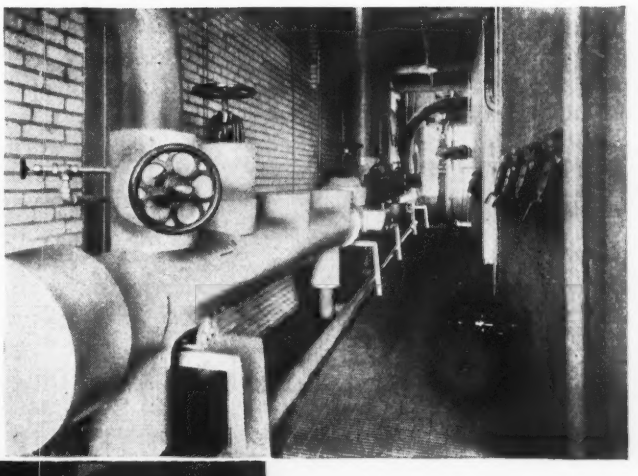
Paddle-type unit pulverizers fire two 4,450-sq.ft. boilers. Zeolite water-softening equipment can be seen in the distance

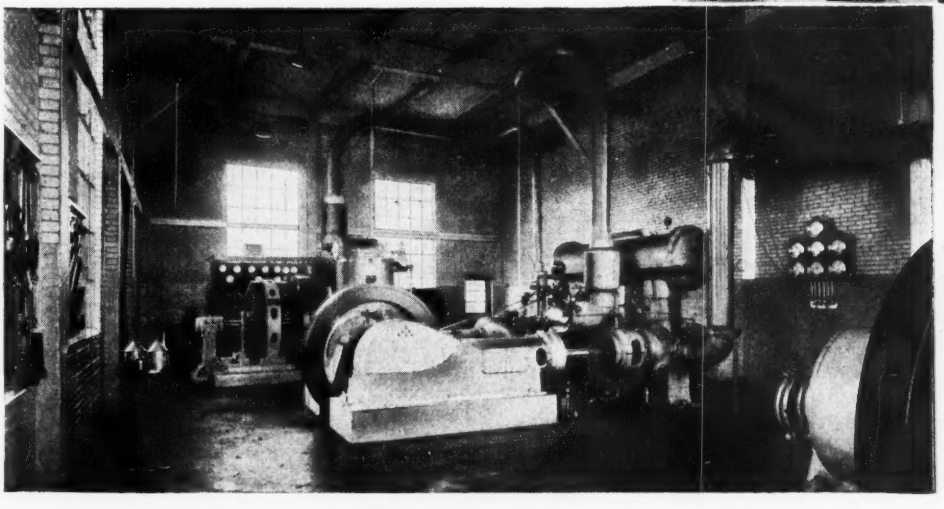
old steam-driven engine generator unit of 100 kw. has been retained as stand-by.

This plant, modern in design and equipment, has been in operation since last November and has consistently met all the varying demands generally associated with important engine house terminals. The terminal plant serves two circular engine houses—the new West house with 25 stalls, and the East house with 30 stalls. In addition, it serves a machine shop, coal pocket, sand drier, engineer's rest building and an office building for the master mechanic.

Densmore, McClear and Robbins, architects and engineers of Boston, designed and supervised the construction of the plant in collaboration with the mechanical department of the Boston & Albany Railroad. Information and photographs were furnished by T. E. Peterson, assistant mechanical engineer, Boston & Albany Railroad.

Ten-inch main steam header, behind boilers, has electrically welded joints





Engine room contains one (1,734 cu.ft. per minute) steam-driven air compressor (in foreground) and a stand-by 100-kw. engine generator unit

...RIGHT OUT OF THE PLANT...

Reactor Dried Out by Using Electric Heater

SOME TIME ago it was deemed advisable, as a precaution, to dry certain high-voltage reactors. This was effectively done by using the equipment shown in the figure. A blower directly connected to a 3-hp., 220-volt motor supplied cold air through a 12-kw., 220-volt heater. One conductor for the heater connected to a contactor was housed in the cabinet shown. In the same cabinet was a contactor thermometer, which actuated, through an auxiliary relay, the heater contactor. The thermometer's stationary contacts were adjusted to energize the heater at 90 deg. C. and deenergize it at 95 deg. The blower motor operated continuously.

This automatic temperature control equipment was normally employed to start and stop the fan motors on an air-cooled transformer. It functioned satisfactorily while applied to oven heat control and maintained the temperature within the limits fixed.

The electric heater was made from resistance grids inclosed in a metal housing. If the flow of air had ceased while the grids were energized they would have become dangerously hot. This was guarded against by connecting the contactor's control circuit to the motor's terminals. With this arrangement a power failure that would stop the motor would also deenergize the heater. Both the blower and heater are intended for permanent use, and are moved where needed.

A baffle box was provided to prevent fire, due to hot or burning materials, entering the oven. Several 2-in. holes were drilled in the sides and top of the oven to

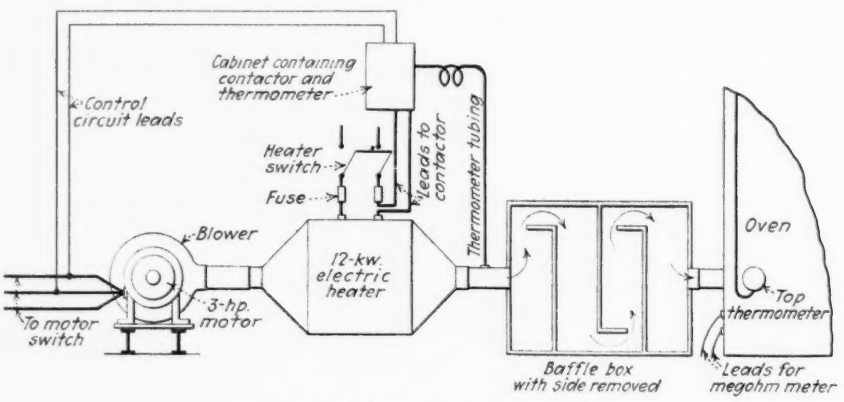


Diagram of equipment for drying reactors

permit of using fire extinguishers, if needed. These holes were filled with wooden plugs.

The oven was made of wood and lined with corrugated asbestos held in place with wooden strips. This material is but little more expensive than ordinary sheet asbestos, yet is a more efficient heat insulator. Instead of lowering the reactor into the oven and then covering the opening, the complete oven was lowered over the reactor, using a crane. Deflectors directed the air upward through the windings. A transformer-type thermometer was arranged to indicate the temperature of the air leaving the top of the oven. This air was about 15 deg. C. lower than the incoming air. A small opening was provided for exit of the air, as a large opening wastes heat and is not necessary to eliminate moisture. Two rubber-covered wires required for obtaining the insulation resistance passed through porcelain tubes in the oven's side. Throughout the drying the insulation resistance was above 5,000 megohms, which was the highest figure on the instrument scale.

RAY BARR GLEN.

Los Angeles, Calif.

Hand Scraping of Bearings

THE ARTICLE by L. H. Morrison on page 742 of the May 12 issue, and the editorial comment in relation to the same subject, "Hand Scraping of Oil Engine Bearings," interests me very much. I, too, am in accord with the no-scraping idea as applied to the bearings of any kind of engine, as well as of must types of power-driven machines. This is particularly so in these days when it is considered that the high-grade tools in use are capable of turning out first-class work.

Some years ago it was considered necessary to scrape bearings to a fit, but even then it was found possible to bore "boxes," as they were called, so they could be placed in the engine without any scraping at all, and yet start off without any signs of heating or distress. When scraping was resorted to, it was necessary to bore the boxes a trifle smaller than the diameter of the journal or pin to which they were to be fitted. But by boring them out a trifle larger than the journal or pin the boxes crown and have enough clearance for an oil film to form, without any need for scraping. This is not a theory or supposition, but a fact that I have demonstrated in several instances on large steam engines. Of course, it should be understood that judgment and skill must be used in deciding just how much larger a bearing should be bored to make a proper job of it.

If the various parts of an engine or any other machine are in alignment there should be no need to use a scraper on the bearings; rather, they should wear themselves in, if wear must take place. However, with proper provision for lubrication, and the correct lubricant applied, little if any wear need take place.

The same thing applies to slide valves and their seats. In former years, particularly in marine-engine practice, slide valves were scraped to a surface, many days being spent in the performance of the job, but I often wondered if the same contact obtained, after the steam was turned on, for the scraping was done when the valve and seat were cold. Scraping produced a glass smoothness that would resist wear, and if the valve warped under the influence of the heat in the steam there was not much hope for obtaining a steam-tight joint between the face of the valve and the surface of the seat.

With the valve seats left just as they come from the plant, the valve face being planed in a direction at right angles to the direction the seat was planed, the valve and seat will wear to each other under steam, a better job can be made of it in that way. Scraping may be all right for precision instruments, and for surface plates and straight edges, but not for the bearings of engines.

Brooklyn, N. Y. CHARLES J. MASON.

What Takes Place in an Airbound Radiator

TO ANALYZE THE OCCURRENCES that take place in an unvented radiator when the steam is turned on (discussed in the Question and Answer column of *Power*, March 24), an actual example will best serve the purpose. Assume a radiator of 1 cu.ft. content filled with air at 60 deg. F., and also that this air is saturated: In the final analysis it does not make any difference whether this air is saturated or only partly humid. The pressure of the saturated air in the radiator is equal to the atmospheric pressure, 29.9 in. Hg., made up of the sum of partial vapor pressure of 0.52. in Hg. and 29.37 in. Hg., the partial pressure of the dry air at 60 deg. F. The weight of the 1 cu.ft. of saturated air is 0.07581 lb., of which the weight of the vapor is 0.00082 lb. per cubic foot, and the weight of the dry air 0.07498 lb. per cubic foot.

The valve is now turned on and steam at 1 lb. gage, 31.94 in. Hg., is applied. Under this pressure the saturated air is immediately confined to a smaller space. The specific weight of the saturated air changes to 0.0810, of which the specific weight of the vapor is the same as before, while the specific weight of the dry air, on account of the increase of its partial pressure, changes to 0.0801 lb. per cubic foot.

The saturated air, therefore, now occupies a space of only $0.07581 \div 0.0810 = 0.936$ cu.ft., leaving $1 - 0.936$ or 0.064 cu.ft. to be filled by the steam. The latter weighs 0.0396 lb. per cubic foot, hence the weight of the steam admitted is 0.00353 lb., containing 4.06 B.t.u. This steam, being about half as heavy as the saturated surrounding air, moves upward, assuming that steam is supplied at the bottom, along the side of the radiator nearest to the entrance. On the way up it is readily condensed giving up its heat of evaporation of 3.41 B.t.u. to the radiator directly and to the surrounding saturated air through conduction and through the agency of the vapor that diffuses into it. Due to the low thermal conductivity of air and the slow rate at which diffusion takes place, only a small fraction of the heat supplied with the steam is absorbed by the saturated air. The majority of the steam admitted condenses in direct contact with the radiator wall surrounding the point of admission and explains the hot zone observed near the supply end of airbound radiators.

Gradually the temperature of the saturated air in the radiator will also increase. Suppose 80 deg. F. is reached. The specific weight of the vapor is now 0.001564 lb. at the partial pressure of 1.029 in. Hg. The partial pressure of the air is reduced to 30.91 in. Hg. and the dry air at this pressure and 80 deg. F. temperature has a specific weight of 0.07596. The specific weight of the saturated air, therefore, is now reduced to 0.077524. Assuming that no air has escaped, the saturated air occupies a volume of $0.07581 \div 0.077524 = 0.979$ leaving $1 - 0.979 = 0.021$ cu.ft. for steam to be admitted, or only 0.00083 lb. of steam. In other words, the amount of steam entering the radiator decreases rapidly as the temperature of the saturated intrapped air increases.

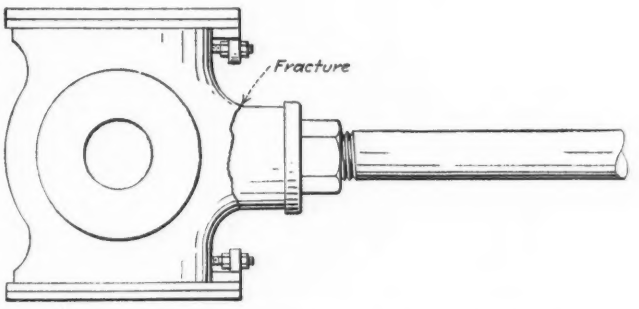
At 90 deg. F. the specific weight of the saturated air is 0.07575, or already less than it was in the beginning. Therefore a state of equilibrium is reached at a temperature less than 90 deg. F. Steam then enters the radiator only at a rate governed by the amount of heat dissipated by the radiator at this temperature. For the purpose of illustration, this temperature may be assumed uniform throughout the radiator. Actually however, due to the fact that diffusion and heat conduction occur at very slow rates, the temperatures and, accordingly, the densities will vary with the distance from the supply end. The above-mentioned temperature, corresponding to the state of equilibrium, represents only an average.

A practically uniform temperature could be attained by the introduction of artificial means which would increase the rate of diffusion and induce heat transfer by convection. Unless conditions surrounding the radiator change or the steam pressure is increased or air is allowed to escape, the radiator temperature and steam flow will remain constant.

Jersey City, N. J. ARNOLD WEISSELBERG.

Crosshead of Ammonia Compressor Breaks

ILL LUCK attended the initial run of a 20-ton refrigerating machine installed in the power building adjoining a newly erected suburban hotel and club house. Two days before the date set for the dedication and formal opening of the institution the crosshead of the compressor failed, as indicated in the accompanying sketch, the boss into which the piston rod was threaded breaking off completely. Instead of searching out the cause of the accident to a definite conclusion, the engineer in charge decided that the accident probably was caused by the machine's taking a heavy slug of liquid ammonia,



Showing break in crosshead of ammonia compressor

combined with the possibility that the erecting man had strained the crosshead by setting up too solidly on the nut that locks the piston rod.

A new crosshead having been secured and connected up, the machine was again started. But no sooner was it fairly in motion than there sounded a thump like the stroke of a trip hammer, and the new crosshead was broken in the same place as the first one. Looking, now, for a cause, the engineer gave the wheel of the stop valve in the discharge line a few turns inward and then backed it out to the limit. Feeling assured that there was no obstruction to the discharge, he next explored inside of the compressor cylinders, but without finding a clue to the difficulty. One of the men then suggested that the bonnet be taken off the stop valve. This was done, and the disk was found off the stem. The valve had been set so that when closed the head pressure would come against the under side of the disk. The object was to permit packing of the valve stem while the condenser was under pressure.

No duplicate of the fractured crosshead was available, and as the delay of casting and machining a new one would be considerable, it was decided to weld the broken one. The stop valve being properly assembled, and the machine in safe running order, the work of refrigeration then proceeded without further mishap, the welded crosshead showing no signs of weakness.

St. Louis, Mo. A. J. Dixon.

Repairing Gas Engine Pistons by Electric Welding

In a recent number of *Power* there was an article by Orville Adams on welded pistons for gas engines.

I was much interested in the article because we have 26 horizontal twin-tandem double-acting gas engines in our plant. The strokes of our pistons, however, instead of being 29-in. varies from 36 to 64 inches.

Considering the 29-in. stroke gas engines discussed by Mr. Adams, I take it for granted that the bore is not more, and possibly somewhat less, than the stroke. Such being the case, his method of shrinking and welding a band or ring on the periphery of the piston would work satisfactorily.

When this process is attempted on larger-diameter pistons the results are not so good. The unequal expansion and contraction in a large piston is sufficient to loosen the shrink fit and cause the welding to crack in the V-groove.

I cannot understand the wear on the periphery of the piston, however. This type of piston is given a definite amount of clearance in the cylinder liner, and consequently should never touch the liner if the proper alignment is maintained. Four of the 26 engines in our plant have been in operation 23 years, and, so far as the records show, a piston has never been lost due to peripheral wear. The blow-by, if any, is always caused by liner wear or broken rings.

Either Mr. Adams is still using the old type of piston rod packing or allows the rod alignment to become very low, otherwise he would not have excessive wear on the bottom side of the piston rods. Furthermore, oval wear of the rod should not cause the piston to drag on the liner, if proper alignment is maintained, because this type of rod is supported on each end by a crosshead and rod coupling or by a coupling and tail guide, all having babbitted shoes. Usually provision is made for shims between the shoe and the rod support for aligning the rods. If the rod alignment is as it should be, I suggest that he use packing known as the follower type which allows the rings to float, thereby reducing rod wear to a minimum.

The idea of building up worn piston rods or other oscillating or rotating shafting which are parts of expensive equipment does not meet with much favor. Considerable experimenting has been carried on in recent years without making much headway. A certain automobile manufacturer tried to weld rods on some of his plant equipment without result. An Eastern steel company also tried to weld piston rods of the same type referred to in the article, but reports state they were unsuccessful.

The company I am with has welded a large number of shafts, with the result that the shafts broke from progressive fracture supposed to have been started by the welding.

Personally I am wondering how Mr. Adams obtains a uniform and homogeneous flow of metal from the welding process. The average welding I have seen is harder in some spots than in others. Rods repaired with this kind of welding wear rapidly and at the same time oval or irregular. The packing also wears rapidly and soon ceases to conform with the shape of the rod.

If Mr. Adams has a process of welding that gives a homogeneous flow of metal, thereby eliminating irregular wear and the possibility of progressive fracture when in service, I should be glad to receive more information about it. I should also be glad to hear from other readers of *Power* interested in the process of repair and salvage by welding.

Chicago, Ill. Roland C. Laney.

What Is the Best Method of Fastening Heavy Belts?

My question in the March 17 number in regard to fastening heavy belts brought forth a variety of replies, a number of which appeared in the April 21 number. A Toronto correspondent described one that I have never seen, and, to be honest, never thought of, though I have prepared a belt for cementing many times in the same way. The one who suggested clipper hooks has never tried them on a wide heavy belt or else he has brought out something that I don't know, and we buy clippers by the thousand box lots, having eight machines throughout the plant.

There is still another method that was not mentioned, though Charles T. Porter describes a similar method in his memoirs. In 1902 I overhauled an old silver mill in Central Nevada which had been built about 25 years previously. Each battery of pans was driven with a 48-in. rubber belt, 12-ply, about 20 ft. between centers, the driving and driven pulleys being about 4 ft. in diameter. Each belt in the mill was connected by a butt joint with a cover strap of the same size belt, 2 to 6 ft. long, according to the size of the belt, and secured by heavy copper rivets $\frac{5}{16}$ in. in diameter with one-inch heads and burrs. Mr. Porter specifies a lapjoint similarly fastened in his memoirs. L. R. Baker.

Cleveland, Ohio.

Field-Winding Short Circuit Causes Generator to Vibrate*

By A. N. SIMMONS
Trenton Channel Plant
Detroit Edison Company

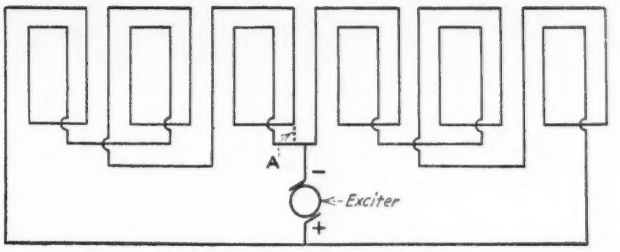


Fig. 1—Diagram of field-coil winding showing short circuit at A

ON SEPT. 26, 1930, after generating 977,801,000 kw.-hr. in about 320 weeks, No. 3 unit in Trenton Channel plant, began to vibrate. The vibration increased to such magnitude that it was necessary to shut down the machine, which is rated at 62,500 kva. The vibrations appeared more pronounced in the generator, but after examining the ends of the field through manholes, attention was directed to the turbine, where the usual inspection is made when a machine is shut down because of vibration. As no cause for the vibration could be found, the machine was again brought up to speed, the freakishness of these vibrations being such that they are quite likely to disappear. However, the vibration continued, and this time it appeared to be more pronounced in the turbine.

Next day a more extensive examination of the turbine and bearings was made. The turbine-generator was then brought up to speed again, having been down long enough for the shaft to straighten if it had deflected as a result of local heating. After an hour's run the machine was shut down because it still vibrated badly, and this time the trouble appeared to be in the generator. The generator's end shields were removed so closer inspection could be made of the end bells, fans and other parts. As everything appeared normal, the generator end shields were replaced, and it was decided to tear down the steam end. Other work on the turbine had been planned, and dismantling of the machine was hastened by this trouble, so that the turbine was completely dismantled before further steps were taken to locate the fault.

A General Electric Company engineer studied operating reports on the generator, examining the field current chart, the voltage chart and the temperature readings. Tests were also made of insulation and resistance of field coils. This engineer was of the opinion that there was nothing wrong with the generator, inasmuch as this company had built and placed in service 77 of that particular design without any reports of trouble from the operating engineers. But to make certain he suggested that the generator be operated as a synchronous motor, while disconnected from its turbine.

The generator was then run from No. 4 generator through a section of the 120,000-volt bus, which had been deenergized, and the fields of each generator were excited from separate sources. The suspected generator came up to full speed quietly, but began to vibrate after a short time and when the field current was increased the vibration became greater, continuing even after the field circuit was opened. The field structure was rotated while cold to determine whether its shaft was true; then field current was supplied and the field rolled again, while hot, to determine wether it was still true.

At last a clue was found: The shaft, when hot, was out of true as much as 0.030 in. 4 ft. in from the bearing. Only one thing could cause this: One side of the field structure must be hotter than the other. Inasmuch as the winding was connected to form two circuits, this seemed likely. But why was the winding clear of grounds? After removing the field structure from the machine current was applied, and one pole was found to be dead, leaving two poles in series in one circuit, and three in the other. This showed where the cause of the trouble lay. With the resistance of one circuit reduced by one-third, the remaining two poles overheated and caused the shaft to bow.

The location of the fault had not yet been found, and several people had used paper and pencil to prove that there could be no trouble in the field without indicating a ground. The diagram shows how this condition is possible when a coil lead is short-circuited to the outside turn of the adjacent coil. A piece was burned out of each of two turns of one coil, making it necessary to remove two coils to make satisfactory repairs. These coils were bent when removed and had to be heated to a cherry red to anneal them so they could be straightened. They were then insulated with mica tape and pressed back into their slots. Connections were made, and the coils dried out for a week by passing sufficient current through them to maintain a temperature of 225 deg. F., this being ample to evaporate all moisture intrapped in the insulation.

When the machine was brought up to speed a few days later both the turbine end and the generator were free of vibration. The unit is now operating as satisfactorily as before the trouble developed.

*Published in the Detroit Edison *Synchroscope* under the title "Diagnosing Turbo-Generator Trouble."

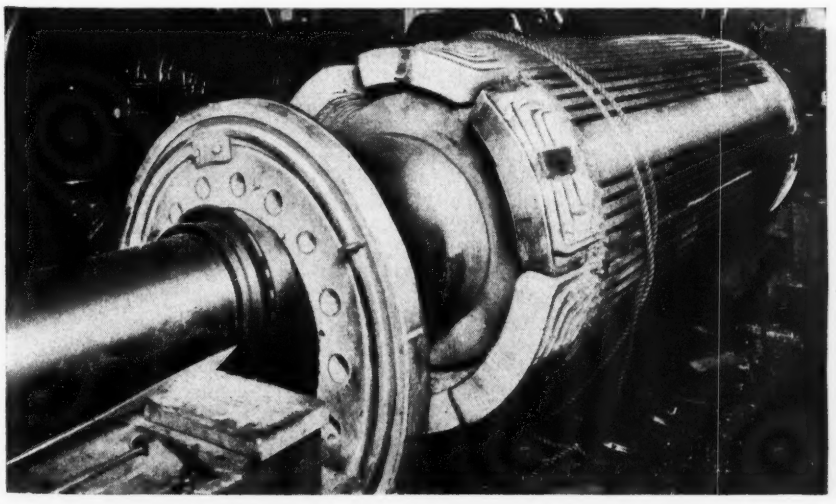


Fig. 2—Rotor of No. 3 generator when the field coils were being repaired to remove the short circuit

Fig. 3—Field coil ready for insulating with mica tape

C.E.A. Convention Has Practical Engineering Program

The engineering section program of the Canadian Electrical Association included reports on electric-steam-boiler operation; fire protection of large oil-filled electrical equipment; painting of under-water structures of hydro-electric plants; troubles in hydro-electric plants; automatic hydro-electric stations; new equipment developments; metering; lamps; and automatic frequency control. Abstracts of the first three reports are given here

AT THE Banff Springs Hotel, Banff, Alberta, the Canadian Electrical Association held its 41st annual convention, June 16 to 18. In the report presented by the electrical apparatus committee, N. D. Paine presented the results of a study made of electric-steam-boiler operation during the last ten years. There is approximately 1,000,000 kw. capacity of electric steam boilers installed in Canada. In one installation, which is the largest, there is 147,000-kw. capacity. These boilers are justified only when a surplus of water power and system capacity are available, or where it is desired to load up a large plant to capacity, the power being later diverted to more profitable loads as they occur.

Operating Experience With Electric Steam Boilers

Operating results are tabulated for 22 installations with units varying in size from 500 to 42,000 kw. and for voltages from 550 to 13,200. The efficiencies of the boilers are given as ranging from 90 per cent for a 2,000-kw., 550-volt, 160-lb. steam pressure, manually controlled unit, to 98.5 per cent for a 10,000-kw., 6,600-volt, 200-lb. steam pressure, manually controlled installation. A large majority of the units operate with an efficiency of 95 to 98 per cent.

One of the chief factors in the efficiency of electric steam boilers is the quality of the feed water. If the feed water is of such a character that heavy bleeding of the boilers is required, the efficiency will be lower than where the bleeding is less, other conditions being equal.

Electrode design has probably received more attention than any other part of the boilers' construction. Various kinds of materials and shapes have been tried, but the most successful appears to be a rod type. The rods are arranged in a cylinder form between two cast-steel hemispheres, the top one being the power connection. For the installations reported on, the electrode life is given as varying from three months to five years, one to two years appearing to be an average value.

The life of the insulators varies similarly with that of the electrodes, although not the same for a given unit. For example, on a 3,600-volt, 5,000-kw. boiler the electrode life is eight months and the insulator life is two years. Just the reverse of the foregoing is found for a 6,600-volt, 10,000-kw. unit that has an electrode life of three to four years and a bushing life of seven to ten months.

The groundplate and bottom head of the boilers are subject to erosion and pitting. Although the life of those parts in several cases is reported as being indefinite, with three 28,000-kw. units it was necessary to renew these parts entirely. In making the repairs, the groundplate was extended to cover the bottom of the tank, allowing proper openings for feed water and bleeding, it being the idea that pitting would be confined to the proper renewable parts.

The formation of hydrogen in electric steam boilers has been the subject of considerable discussion. In only one of the twenty-two installations investigated was excessive hydrogen reported. In this case hydrogen is excessive if all raw make-up water is used. If condensate is used for feed water the amount of gas generated is nil.

The maintenance cost on the boilers is low, ranging from about 1.4c. to 0.016c. per 1,000 lb. of steam produced. The latter is for the largest installation of electric steam boilers in Canada, and has until recently been operated to supply all the steam to a 600-ton pulp and paper mill.

Fires in Oil-Filled Electrical Equipment

Another interesting report was that of the committee on fire protection of large oil-filled electrical apparatus. Data were obtained from twenty-three companies in Canada, of which eight reported twelve oil fires. Data on seven additional oil fires taken from United States insurance reports were included, making a total of nineteen oil fires on which information was obtained. Of the nineteen oil fires reported, fourteen involved transformers ranging in size from 40 to 7,000 kva. Four fires were reported in oil circuit breakers, of which three were rated at 110,000 volts. One fire was reported in a 110,000-volt electrolytic lightning arrester.

In five cases the fires started outside and the other fourteen started inside the equipment. Of the five fires originating outside, two were started by raising the temperature of the oil in the transformers by external heat. A third was started by an oil-insulated balance coil failing and short circuiting part of the transformer winding. A high-tension bus fell on a transformer, the resulting arc breaking the conservator gage glass, igniting the oil and causing the fourth fire. A cable failed, the arcing burned a hole in the transformer and resulted in the fifth fire.

Of the four fires starting inside oil circuit breakers, one was due to contacts heating; one was caused by an explosion that threw out a quantity of burning oil when rupturing the arc; one developed from a failure to rupture a heavy current, causing the arc to ignite the oil; and the fourth was caused by the oil tank dropping so that the contacts opened in air and the arc ignited the oil.

Four of the transformer fires were due to breakdowns in the equipment, and the resulting arc ignited the oil. Too short a clearance between the high-tension leads and the tank resulted in an arc that ignited the oil. A short circuit in the winding caused one of the fires, and an overload caused another. Rust scale falling from the underside of the manhole cover, on to the terminal board, caused a short-circuit that ignited the oil. The ninth fire was from oil leakage lowering the oil level below the terminal board when a flash-over occurred and set the oil on fire.

The reports on extinguishing the fires were not very favorable for the method used in fighting oil fires of this kind. Several of the fires continued until they burned themselves out, notwithstanding the application of various types of extinguishing equipment.

In all but two cases the amount of damage was far greater than the value of the electrical equipment in which the

fire started. Based on a conservative estimate, the average property damage per fire is $15,500. The opinion is expressed that a large part of this damage could have been prevented by adequate drainage systems for carrying away the burning oil. When practicable, oil-filled apparatus should be set on a floor sloping toward a drain of such proportions that the burning oil will escape before the fire has had time to do serious damage.

Surrounding the foundations of outdoor apparatus with a bed of crushed stone or gravel for cooling and draining the oil during a fire is considered an excellent and cheap form of protection. The crushed-stone bed should be large enough to hold all the oil contained in the equipment, and provision should be made for draining it into a sump from which it may be pumped out. If natural drainage is such, the oil may be allowed to run away from the gravel bed.

Painting of Under-Water Hydro Structures

An extensive report by the hydraulic power committee was presented on the painting of under-water structures in hydro-electric plants. The conclusions given in this report are as follows:

So many factors enter into the selection of protection for under-water surfaces of steel that careful consideration of these factors is necessary for a proper protection of the surface against deterioration.

Paints for under-water protection require especially careful selection for the various conditions to be met, and extremely careful application on both new and old work to insure a reasonably long life.

Conclusions do not appear finally crystallized upon the advantages of metallic coatings. Paint, being readily obtainable commercially, and economically applicable to large surfaces, is the most serviceable material for protection.

It appears that considerable study and accumulated experience is necessary to produce a paint with reasonable length of life to withstand under-water conditions. Such study is being given to various paints by a number of workers both in Europe and America.

Operators and those concerned in maintenance of exposed steelwork can materially assist the manufacturers by reporting practical experience with paint under various conditions, and the manufacturers may encourage such reports as tending to consolidate and improve the quality of built-up paint films.

Advantage should be taken of United States Government and A.S.T.M. specifications for pigments and water-resisting paints and varnishes, and of British Engineering Standards and Canadian Engineering Standards for Painting Steel Highway Bridges.

After all ascertainable factors are considered, the selection of paint, for extreme conditions, is still a matter of compromise one way or another, and the results obtained are likely to be improved by practical experience of methods of application and composition of paint. This does not mean that results by hit-and-miss methods are to be commended for selection of paint or as being likely to prove as reliable as those following proper investigation and careful correlation of data, but indicates that no definite formula can be given for the selection of paint without knowledge of surrounding conditions.

▼ ▼ ▼

Anti-Friction Bearing Lubrication Investigated

At the 27th annual convention of the Association of Iron and Steel Electrical Engineers, held in Cleveland, Ohio, June 15 to 16, a preliminary report was presented by the committee on bearings, F. D. Egan, chairman. On the lubrication of anti-friction bearings in motors, the report states that it has developed, since operating experience has become more general with the placing in operation of more mill motors equipped with anti-friction bearings, that consideration must be given to several operating conditions to insure success of these motors. The mill motor manufacturers are rating the compound- and shunt-wound motors for relatively high speeds, and the tendency of machinery builders is for higher-speed motors. This, in turn, imposes relatively high peripheral speed on the raceways of the anti-friction bearings, particularly in larger sizes.

The use of higher-speed motors also aggravates the problem of anti-friction-bearing lubrication and safe operating temperatures for these bearings. Very little reliable operating information is available on temperature rise and maximum temperatures for anti-friction bearings on mill motors. In some cases customers became concerned about safe operation of motors with anti-friction bearings, due to heating in the bearings, and the motor builders were not in a position to advise what is the maximum safe operating temperature for the bearings.

In one instance a test was conducted on a mill-type motor equipped with No. 319 roller bearings running light on test block at 1,200 r.p.m. to measure on thermometers the maximum bearing temperature and temperature rise above ambient. The peripheral speed of the bearings was computed at 1,570 ft. per minute with the motor running at 1,200 r.p.m. The bearing temperature was measured with mercury-type thermometers inserted in the bearing cartridge through holes for grease fitting. The test was conducted under two different conditions of lubrication. First the bearings were run and the temperature measured for lubrication as in bearings from the motor factory. A maximum temperature rise of 120 deg. F. above ambient was obtained under these conditions. Next, the original lubricant was washed out of the bearings and replaced with another grade of grease. In this instance the maximum bearing temperature obtained after operating the motor at 1,200 r.p.m. for 3 hr. was 76 deg. rise above the ambient temperature. These tests indicated a difference of 44 deg. temperature rise for the two grades of lubricant.

It has been suggested that oil is a more satisfactory lubricant than grease for anti-friction bearings operating at relatively high speeds and temperatures. The argument in favor of this idea is that grease disintegrates under conditions of high speed and temperatures, thereby losing its effectiveness as a lubricant, causing additional heating and tending toward early failure of the bearings.

From an operation standpoint, the introduction of oil lubrication in these bearings defeats one of the prime reasons for using anti-friction bearings on electric motors. At high speeds the oil tends to vaporize and leak out of the bearings, saturating the commutators and windings of the motors and tending toward early winding failures. For this reason it is felt that anti-friction bearings which could be satisfactorily lubricated with grease would insure longer motor life.

The problem of lubrication, maximum speed determination, and heating of anti-friction bearings on mill motors is further complicated by conditions surrounding the drive. In many instances considerable thrust is imposed axially on the armature shaft from helical gearing, inclination of motor base or some other condition of the drive. The thrust condition develops additional heating in the motor bearings unless a special thrust bearing is provided.

The special committee on bearings is endeavoring to obtain a composite opinion of the operating men, motor manufacturers and bearing manufacturers, relative to heating, thrust and lubrication of anti-friction bearings when operating at high speeds, by a questionnaire to the members of the Association of Iron and Steel Electrical Engineers. It is expected that this information will be developed and ready for publication at some future date.

▼

In the article "Waste Heat Recovery in Oil Engine Plants," in the June 9 number, the caption of Fig. 4 referred to a Cochran vertical waste heat boiler. This should have been a Spencer-Bonecourt boiler.

Heating With Exhaust Steam

By PERRY WEST*

WASTE HEAT should be used for heating and ventilating requirements wherever it is available. The sources of such waste heat include electric or power generation, industrial and condensing processes, and furnace gases.

Where heat and power or electric current are required the steam may first be used for generating the power, and the exhaust from the generating unit may be used for heating. The way in which the quantities of exhaust steam produced, and the quantities of steam required during the various intervals of time throughout the year coincide will determine how much may be used, how much must be thrown away, and how much live steam must be used to supplement the exhaust steam deficit, unless some means is adopted for adjusting the supply to the demand.

One method of making this adjustment is to store exhaust steam, or its equivalent in heat, when it is in excess of the demand, and feed this to the system when the exhaust being produced is below the demand. Hot-water accumulators may be used for this purpose by storing heat in water to be fed to the boilers, the water to be used for domestic hot-water service, hot water heating system, process work, or for some combination of these purposes.

Another method is to adjust the quantity of exhaust produced somewhat in concordance with the heating demand. A bleeder turbine from which the exhaust may be taken for the lower heating demands, and additional higher-pressure steam from its successive stages as this demand goes up, is frequently a satisfactory solution for a case where the normal exhaust is deficient. If such a turbine is also arranged to run condensing under various controllable degrees of vacuum, and arrangements are made for either circulating the exhaust through the heating system under various pressures above and below atmospheric pressure, or for similarly using the exhaust for heating water, such an arrangement may adjust the exhaust to a wide variation of heating demands.

With such an arrangement the exhaust supply may be automatically adjusted to the demand by having automatic control of the vacuum in the turbine from an outdoor thermostat operating on the flow of cooling water to the condenser, and remote control valves in the bleeder steam supplies controlled from the same or a coordinate thermostat. A modification of this method of adjustment, especially as between the heating and non-heating seasons, is to use engines or turbines which may be run condensing throughout the non-heating season, and non-condensing throughout the heating season.

Still another method is to adjust the heating demand so that it will balance as nearly as possible the exhaust steam produced. The use of hand operated or automatic remote-control sectional, or zone, regulating valves for separately controlling the various sides and vertical sections of a building in accordance with the exposures, wind velocities, sunshine, etc., the use of automatic temperature control, fractional distribution of steam, distribution of steam under varying degrees of vacuum and the use of forced hot water with temperature control, all tend to keep the demand commensurate with the actual weather requirements, thereby reducing the maximum demand, and at the same time the amount of fluctuation, by supplying heat only where it is needed.

The question of relative economy and cost must necessarily enter the problem, and the first step is to estimate for the

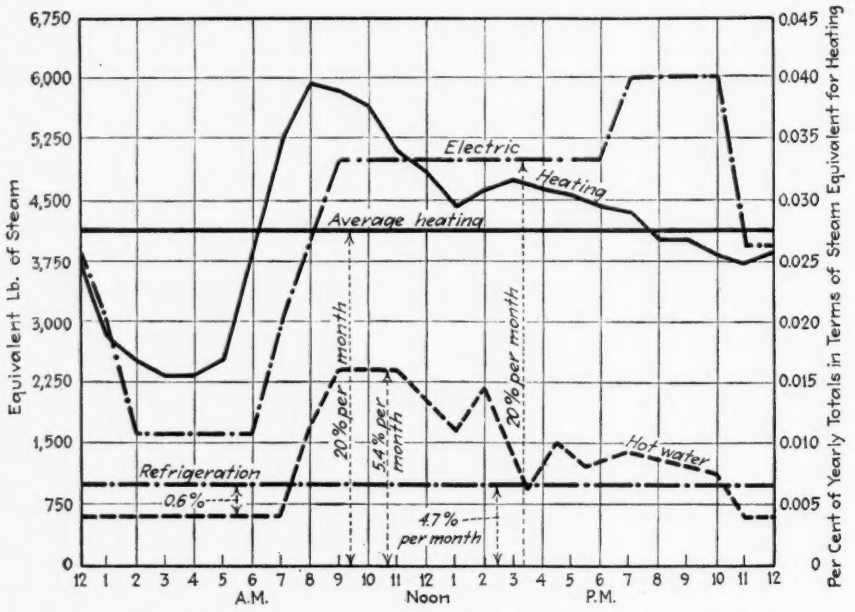


Fig. 1—January and February load curves for 500-room hotel in terms of steam equivalent for heating

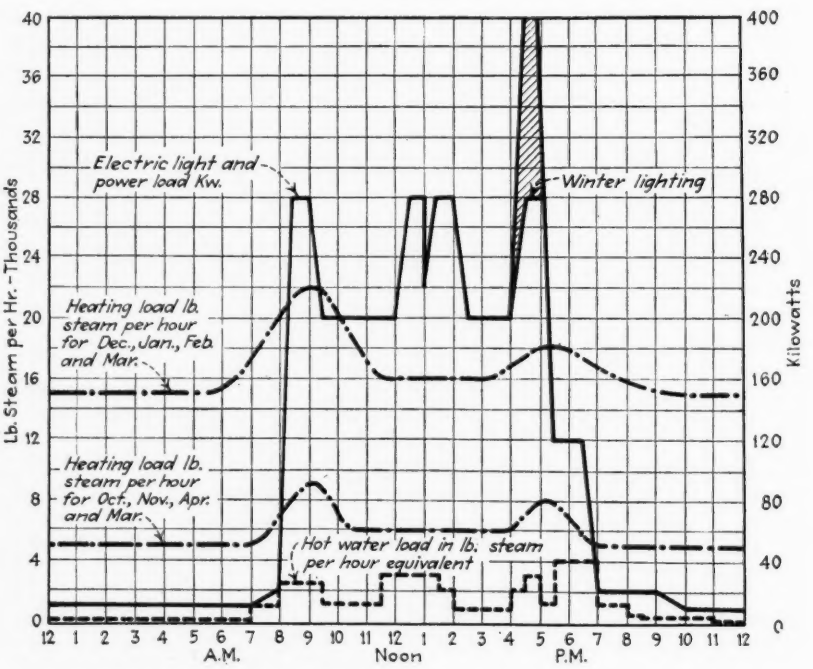

Lb. Steam per Hr.-Thousands
Kilowatts
Electric light and power load Kw.
Winter lighting
Heating load lb. steam per hour for Dec., Jan., Feb. and Mar.
Heating load lb. steam per hour for Oct., Nov., Apr. and Mar.
Hot water load in lb. steam per hour equivalent
A.M.
Noon
P.M.

Fig. 2—Power and heating load curves for office building

*Presented at the annual meeting of the A.S.H.V.E., 1931.

various hours of the day and night, and for various days of the year, the power load and heating requirements. Generally, a 24-hr. electrical load and heating requirement chart for each of the four seasons of the year will be sufficient, although in many cases the load may be different for some days of each week. Figs. 1 and 2 represent typical load curves, one for a 500-room hotel, and the other for an office building. In the hotel diagram it will be noted that the steam required for generating the refrigeration power is shown separately, and is not included in the steam required for generating the remaining electric current or power. This is for the purpose of comparing it with the hot-water load, which it practically equals. For this reason the refrigerating apparatus in this class of building may frequently be steam driven, and the exhaust thus produced be used with good economy for heating the domestic hot water, even where the remainder of the electric current is purchased from the outside, and steam or hot water direct from the boiler plant is used for heating.

In making up these charts it is necessary to estimate the steam required for heating per square foot of direct radiation, or its equivalent, per season. Factors that help in making these estimates for different classes of buildings are as follows:

For manufacturing or commercial loft type, where steam is used to heat the premises during the day hours to maintain 65 to 68 deg. F. from 9 a.m. to 5 p.m. No Sunday or holiday use and no night use. Factor: 325 lb. per square foot of radiation per season.

For office buildings using steam during daylight hours only to maintain 70 deg. F. from 9 a.m. to 6 p.m. for approximately 240 days (heating season). No night use. Factor: 400 lb. per square foot of radiation per season.

For office buildings using steam during day hours and at night when required to 7, 8 and 9 p.m. (customary where there are stock brokers or banking offices), 204 days. Factor: 500 lb. per square foot of radiation per season.

For apartment houses where high-class heating service is required. (Steam off at midnight.) Factor: 650 lb. per square foot of radiation per season.

For hotels (commercial type) where very high-class service is required; 24-hour service. Factor: 800 lb. per square foot of radiation per season.

Of the total steam required for any particular service, the following percentages of the whole may be apportioned to the various months of the heating season in the colder climates: January, 20 per cent; February, 20 per cent; March, 15 per cent; April, 10 per cent; May, 5 per cent, October, 6 per cent, November, 8 per cent; December, 16 per cent.

To determine the amount of exhaust steam available for heating, it is necessary first to develop electric current or power load curves for the same period. From the load curves the exhaust steam available for heating may be obtained by reference to manufacturers' turbine and engine steam rate data, or by calculation from ideal water rates for the engine under the particular pressure conditions it is to operate, and engine efficiency data.

▼ ▼ ▼

Developing South Africa's Water Powers

SOUTH AFRICA'S rivers constitute an undoubted source of wealth, but they are also the subject of several illusions. It is often said that the Victoria Falls is the cheapest source of power in South Africa, and that it is superior in this respect to Niagara Falls, which has been developed for power generation. As a power source, Victoria Falls is undoubtedly inferior to the American cataract. It may be twice as broad and more than twice as high, but power generated there has to be transmitted hundreds of miles to the Rand before it can be used on a large scale. This necessity would increase its cost above that of power from coal at present serving the needs of the Rand.

Niagara Falls is located in the center of a prosperous and thickly populated region. Many large industries are carried on in its immediate vicinity, and a much greater use is made of electricity than in South Africa. Electric lighting and power is a dream of the distant future for South African farmers: in America it is a common element of agricultural life in many districts.

South African rivers and the Victoria Falls might be made the source of power for smaller electrical undertakings that would show a profit. In such a country, with droughts and water difficulties, these schemes would be interconnected. When shortage of water power is compensated for by current from steam-power plants, power supplies can be maintained. Dependence upon water-power plants alone means periodical suspension of operations, especially during long droughts.

The time may come when Rhodesia will make extensive use of electrical power, but that country requires a much larger European population and a greater influx of natives than at present. It is estimated that forty natives are required to equal the needs of one European. Electrical engineers believe that even now it may be practicable to run a power line from Victoria Falls as far south as Kimberley. Other lines from this would be led off into various farming areas, and where at present expensive pumping plants are being run, cheap electric apparatus could be used. The success of such a scheme depends upon a large guaranteed load.

Waste of energy in transmission is a serious stumbling block to such an undertaking, and even at one-quarter or one-half million volts it is still serious. Something more than the present high-tension transmission systems must be found before South Africa's water power can be utilized extensively. None the less, the time must come when, with decreasing supplies of coal and other mineral fuel, man will be forced to utilize natural forces like the Victoria Falls and to devise efficient means of distribution.

ENERGY AVAILABLE AT VICTORIA FALLS

Opinions of experts differ about the amount of energy available at Victoria Falls. It is generally held, however, to be equal to that required to drive all industrial plants, the railways and all domestic supply centers in South Africa and Rhodesia. Without coal supplies so favorably situated and so extensive, some use would have been made of the rivers long ago. The other important respect in which South African rivers can be harnessed is by turning them more to irrigation purposes.

Those who would make the greatest possible use of South African rivers propose the erection of hydro-electric plants at stragetic locations, where water can be pumped to fertile levels. It has also been proposed that the dry rivers of the Kalahari be filled by sending surplus water northward through the Gamagara to the Kuruman and Malopo rivers and back to the Orange River. In this way a few hundred miles of alluvial soil would be opened for cultivation. The Orange River could undoubtedly be developed in the same way as has been done with the Nile.

Great developments have already taken place in the Orange River valley between Kakamas and Upington. Cotton and sultana growing has been taken up extensively, and much of the land devoted to such crops is low-lying islands and riparian ground. Grain, fruit and vegetables are also planted extensively along these stretches of alluvial soil. At present much of this cultivation is done by small holders, hundreds of whom are earning excellent incomes, but if the waters of the Orange River were utilized fully farming on a large scale would be possible. About half a dozen schemes are under consideration.

▼

IN THE REPORT of the N.E.L.A. convention published last week in *Power*, page 969, reference was made at the top of the middle column to the fly-ash content of gas streams in "grams" instead of "grains" per 1,000 cu.ft. The sentence should have read: "The first plan was to state that more than 200 grains of solids per 1,000 cu.ft. of gas was a nuisance. This was later changed to 300 grains and on further consideration to 400 grains."

From Among Readers' Problems

Conducted by
L. H. MORRISON

WEIGHT OF AIR IN CONDENSER—*What is the percentage in weight of air in a condenser when the absolute pressure is 4 in. of mercury and the temperature of the air vapor mixture is 103 deg. F.*
M. D. A.

From the steam tables the pressure of the vapor corresponding to 103 deg. F. is 2.107 in. of mercury. Hence the air pressure of the mixture is $4 - 2.107 = 1.893$ in. of mercury.

The density of the steam at the stated temperature is given in the steam tables as 0.003104 lb. per cubic foot.

The density of the air at 0 deg. F. and standard barometric pressure (29.92 in mercury) is 0.08635 lb. per cubic foot. Therefore the weight of dry air per cubic foot of the mixture is

$$0.08635 \times \frac{1.893}{29.92} \times \frac{460}{460 + 103} = 0.00446 \text{ lb.}$$

Hence the total weight of the mixture is $0.003104 + 0.00446 = 0.00755$ lb. per cubic foot and air in the mixture constitutes $\frac{0.00446}{0.00755} \times 100 = 59$ per cent of the total weight of moisture and air.

—❖—

CUTTING A COIL OUT OF INDUCTION-MOTOR STATOR WINDINGS—*How is a defective coil cut out of the stator winding of a 220-volt, 3-phase, 60-cycle induction motor? I have tried disconnecting the coil and connecting together the two leads from the other coils that connected to it. In one case this worked satisfactorily and in another two more coils burned out.*
H.A.T.

The results of cutting out a coil in an induction motor's winding will depend upon how the winding is connected. For example, assume a 10-pole, 3-phase winding with four coils per pole-phase group. If this winding is connected series-star there will be 40 coils in series in each phase. If a coil is cut out of one phase the winding will be unbalanced with the other two by only 2.5 per cent. Since the winding is connected in star with the other two, cutting the coil out has reduced the voltage the winding is good for, by only about 1.5 per cent. If the motor were connected series-delta, cutting a coil out of one phase would reduce the turns in this part of the winding by 2.5 per cent and throw the winding out of balance by this amount and cause circulating currents. The circulating currents in this case would not be serious.

Assume that the winding is connected 10-parallel star. With this connection there will only be four coils in series in each parallel circuit. If one coil is cut out, the number of turns in that circuit will be reduced 25 per cent. This condition would produce an excessive current in part of the winding and cause it to overheat and burn out. From the foregoing it is evident that the effect of cutting a coil out of the winding will vary widely, depending on how the winding is connected. In the last example, if the motor was partly loaded it might be possible to cut out the defective pole-phase group of coils and operate until such time when the motor could be taken out of service for repair.

When a short-circuited coil is disconnected from the winding, it must be cut in two at one end. If this is not done a current will be induced in this coil that will cause it to overheat and may damage other coils adjacent to it.

PREVIOUS QUESTION DISCUSSED BY READERS

THE QUESTION

WITHDRAWAL of water from a tank placed in the suction line of a centrifugal pump is to provide sufficient vacuum when the pump starts to fill the empty suction line and to supply the requirements of the pump in the meantime.

At the outset the suction line will be full of air at atmospheric pressure and the pump will deliver 500 g.p.m., which will diminish continuously for two minutes to 300 g.p.m. The suction line consists of 25 ft. of 5-in. pipe, with 3 ells, and the highest static lift is 15 ft. Cold water will be used.

Assuming the tank full of water to begin with, what must be its minimum capacity? What would be the size if the tank contained only 90 per cent water?
T.A.

TO FIND THE SIZE of the tank required in this question, it is first necessary to determine the volume of the suction line to be filled.

Area of pipe $= \frac{3.1416 \times 5^2}{4}$
$= 19.63$ sq.in., or 0.136 sq.ft.
Length of pipe = 25 ft.
Volume of pipe = $25 \times .136 =$ 3.40 sq.ft.
Volume of ell with pipe made up = 0.080 cu.ft.
Volume of three ells = $3 \times 0.080 = 0.24$ cu.ft.
Total volume of pipe and ells = $3.40 + .24 = 3.64$ cu.ft.
Total head in pipe = $14.7 - (15 \times .434) = 8.2$ lb. per sq.in. abs.

Case I, where tank is full at start:

$$\frac{P}{P_1} = \frac{V_1}{V}$$

Where P = Atmospheric pressure.
P_1 = Total suction pressure.
V = Volume of suction pipe.
V_1 = Volume of suction pipe plus necessary tank volume

$$\frac{14.7}{8.2} = \frac{V_1}{3.64}$$

$8.2\ V = 53.50.$
$V_1 = 6.53.$
Necessary volume of tank = $6.53 - 3.64 = 2.89$ cu.ft.

Case II, where tank is only 90 per cent full at start:

$$\frac{P}{P_1} = \frac{V_1}{V}$$

P and P_1 are same as in Case II
V_1 = Necessary volume of tank plus volume of pipe.
$V = 3.64 + 0.1(V_1 - 3.64)$
$V = 3.64 - .364 + 0.1V_1$
$= 3.276 + 0.1V_1$

Substituting:

$$\frac{14.7}{8.2} = \frac{V_1}{3.276 + .1V_1}$$

$8.2V_1 = 48.157 + 1.47V_1$
$8.2V_1 - 1.47V_1 = 48.157$
$V_1 = 7.15$ cu.ft.
Volume of tank = $7.15 - 3.64 = 3.51$ cu.ft.

The capacity of the pump does not seem to have a direct effect on the size of the tank required, since it is stated that the highest lift is 15 feet.

I have not considered vapor tension of the water in answering this question, since it was stated that the water was cold. The effect of vapor tension would be very small, and if the tank is made of 3.5 cu.ft. capacity in the first case and 4 cu.ft. capacity in the second case it should prove satisfactory.

R. F. SORRELLS.

Beaumont, Texas.

THE FIRST THING is to find the contents of the pipe. Allowing 10 in. of pipe for each elbow, the contents of the pipe and elbows will be (area of 5-in. pipe) $\times$ (25 + 2.5) $\times$ 12 = 6,600 cu.in. of air.

The tank will have to be big enough to contain that much air when it is expanded under the vacuum necessary to cause the flow of water into the tank. The vacuum will have to be high enough to overcome the static lift plus the lift due to the friction of the water in the pipe.

At 500 g.p.m. the rate per second will be $500 \div 60 = 8\frac{1}{3}$ gal. per second, and the velocity in the pipe would be

$$\frac{24.51 \times 8\frac{1}{3}}{5^2} = 8.17 \text{ ft. per second.}$$

The friction of each elbow is equal to the friction of a pipe whose length is 60 times its diameter.

The elbows will then be equal to $3 \times \frac{5 \times 60}{12}$ or 75 ft. of pipe.

The friction lift of the pipe plus the elbow is:

$$\frac{0.02 \times (25 + 75) \times 8.17^2}{5.36 \times 5} + 0.0233 \times 8.17^2$$

which gives 6.53 ft. The total lift is

$$15 + 6.5 = 21.5 \text{ ft. or } 21.5 \times 0.434 = 9.33 \text{ lb.}$$

The absolute pressure in the tank is 14.7 — 9.3 = 5.4 lb.

Six thousand six hundred cubic inches of atmospheric air, when under only 5.4-lb. pressure absolute, will expand to $\frac{6{,}600 \times 14.7}{5.4} = 17{,}966.6$ cu.in., or 77.7 gallons.

The rate of flow through the pump will decrease from 500 g.p.m. to 300 g.p.m. in two minutes, or $\frac{500 - 300}{120} = 1\frac{2}{3}$ g.p.m. for each second.

While pumping 77.7 gal. the rate in gallons per minute will have decreased $(77.7 \div 8\frac{1}{3}) \times 1\frac{2}{3} = 15.53$ gallons.

The rate of flow when the tank is nearly empty will be 500 — 16 = 484 g.p.m. The flow in the suction pipe will never be greater than 484 g.p.m., so the friction lift will be less than that at 500 g.p.m.

Figuring the problem again, for this rate of flow the friction lift becomes 6.1 feet.

The absolute pressure in the tank will be

$$14.7 - [(15 + 6.1) \times 0.434] = 5.6 \text{ lb.}$$

When reduced to 5.6 lb. pressure absolute 6,600 cu.in. of air will give $\frac{6600 \times 14.7}{5.6} = 17{,}325$ cu.in., or 75 gal. This will be the minimum capacity of the tank.

I am taking for granted that the remainder of the tank, which will contain only 90 per cent of water, will be full of air at atmospheric pressure.

Using the same water velocity in the pipe the resulting absolute pressure in the tank will be the same as in the preceding case.

The ten per cent of air in the tank, when expanded to 5.6 lb. absolute pressure, will occupy $\frac{10 \times 14.7}{5.6}$, or 26.25 per cent of the tank.

The remainder of the tank will be occupied by the air that was originally in the pipe; therefore 100 per cent equals $\frac{6{,}600 \times 14.7}{5.6} \div 0.7375 = 23{,}491.5$ cu.in., or $101\frac{1}{4}$ gallons.

The minimum capacity of the tank full of water will be 75 gal., or 10 cu.ft.

The minimum capacity of the tank with only 90 per cent of water will be $101\frac{1}{4}$ gal., or 13.5 cubic feet.

ARTHUR E. FORTIN.

Greenville, N. H.

TO RAISE THE WATER to the pump inlet a vacuum will have to be produced in the tank, and the size of the tank depends upon the vacuum required.

From the rates of flow given in the question, the average pump discharge would be 400 g.p.m., and we shall assume the average flow through the suction line to be the same. The friction loss through the 5-in. suction line will be 5.33 ft. per 100 ft., or 1.333 ft. and the similar loss through the ells will be 0.66 ft. $\times$ 3 = 1.98 ft.

The velocity head $= \frac{V^2}{2g} = 0.657$ ft.

Assuming an entrance loss of 0.5 ft., the total dynamic suction lift will be 19.47 feet.

This will require a pressure difference of 8.46 sq.in., or an absolute pressure inside of the tank of 6.24 lb. per square inch.

Therefore $P_1V_1 = P_2V_2$

Where $P_1 = 14.7$ lb. per sq.in. abs.

$P_2 = 6.24$ lb. per sq.in. abs.

$V_1 =$ Vol. of air in pipe = 3.41 cu.ft.

$V_2 =$ Volume of tank plus volume of air in pipe.

$$V_2 = \frac{P_1V_1}{P_2} = \frac{14.7 \times 3.41}{6.24} = 8.025 \text{ cu.ft.}$$

8.025 — 3.41 = 4.615 cu.ft., or 34.5 gal., as volume of tank.

In the second case P_1 and P_2 would remain the same, but V_1 and V_2 would be increased.

$V_1 =$ Volume of air in pipe plus $\frac{1}{10}$ tank volume

$V_2 = V_1$ plus $\frac{9}{10}$ tank volume

$$V_2 = \frac{P_1V_1}{P_2}$$

$$(3.41 + .1V_t) + .9V_t = \frac{14.7\ (3.41 + .1V_t)}{6.24}$$

from which $V_t = 6.06$ cu.ft., or 45.3 gal. as volume of tank.

In both cases the tank size is theoretical; in actual practice a larger size tank should be used.

EDWARD B. CARY.

Shaker Heights, Ohio.

THE VOLUME of 25 ft. of 5-in. pipe and three ells is 3.8 cu.ft. The pressure drop in the pipe when handling 500 g.p.m. would be about 3.5 ft. of water, and, since the static lift is 15 ft., the difference between the atmospheric pressure and the pressure in the tank must be at least 18.5 ft. Atmospheric pressure is equivalent to 34 ft. of water, therefore, the pressure in the tank must be not more than 15.5 ft. (absolute) to make the water flow into the tank at the required rate. In the first case, with a full tank, the minimum volume theoretically required would be $\frac{3.8 \times 34}{15.5} = 8.3$ cu.ft.

However, to take care of the inertia of the water when starting and to allow for some water storage the tank should have not less than 100 gal. capacity.

If the tank is only 90 per cent full the volume theoretically required would be 8.5 cu.ft. For the reasons given above, the capacity should be at least 150 gallons.

Unless the water being handled is free from entrained air the pump will eventually lose its suction due to the releave of air from the water under reduced pressure. R. T. VAN NESS.

Wilmington, Del.

A Question for Our Readers

WE HAVE a 1,800 r.p.m., 125-g.p.m., multi-stage centrifugal boiler-feed pump in our plant and I am told that unless there is absolutely full opening in the discharge line the pump will have a tendency to lose the balance thrust and thus ruin the impellers. My contention is that as long as there is any circulation of water through the pump, even if the flow is restricted, the pump will operate without danger. We are at present operating as a stand-by station and use approximately 70,000 lb. of steam per 24 hr. The steam demand is fairly constant. Can this pump be operated by throttling the discharge without danger of ruining it? E.S.Y.

Suitable answers from readers will be paid for and published in the July 28 number

WHAT'S NEW IN PLANT EQUIPMENT

Spiral Welded Pipe

SPIRAL welded pipe in jointless lengths to 40 ft. is a recent development in the line of pipe put out by the American Rolling Mill Company, Middletown, Ohio. The pipe lengths are made of one continuous strip of metal wound spirally and welded along the seam; a slightly heavier

Pipe with spirally welded seam

weld than actually necessary, is used to give the pipe unusual stiffness and rigidity.

Important features of this pipe as pointed out by the manufacturers are: the pipe is straight, smooth inside and light in weight, there are no interior grooves nor ridges and every joint is round.

This pipe is now available in sizes ranging from 6 to 24 in. in diameter in all wall thickness from No. 12 gage to $\frac{3}{8}$ in. It can also be had with any type of coating desired—mill coat, asphalt inside and out, or galvanized.

Steel Tubes With Cast Alloy Linings

STEEL TUBING lined with a variety of metals or alloys in which the bonding of the two metals by fusion is said to be so completed that there is no evidence of separation and no manual means of destroying the union is announced by the Detroit Seamless Steel Tubes Company, Detroit, Mich.

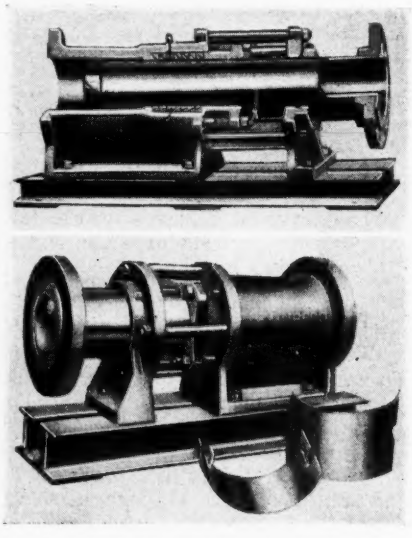
One of the important advantages of this construction is in the production of steel-backed bearings. Any specified thickness of bearing metal can be accurately controlled and tubes in lengths up to 16 ft. can be fabricated. Thus bearings of various lengths can be readily cut from one tube.

Other uses to which tubing so lined can be put are for conveying corrosive liquids, tubes for water-tube boilers where a lining metal of high heat conductivity is advantageous and water pipes to replace copper tubing where strength is an important factor.

Heavy-Duty Expansion Joint

A PERMANENTLY FIXED extension guide rigidly attached to the body of the joint proper is an important feature of the Murfco expansion joint illustrated. This extension precludes any chance of misalignment and increases the life of the packing.

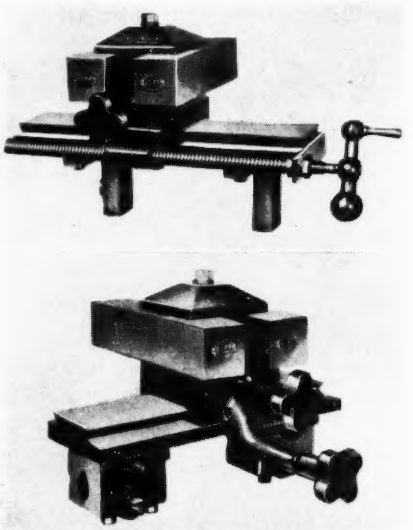
Another important feature is the method of lubricating the sliding sleeve. Standard pressure fittings lead a charge of zinc oxide lubricating compound under pressure through a metal distributing ring, forming the lubricant into a thin film between the packing and sliding sleeve. Hence the packing is impregnated and retained in a soft, pliable and resilient condition. The complete joint is mounted on a structural-steel base and a sheet-metal cover protects the sliding sleeve against dirt. The joint is manufactured by the Murphy Machine Company, Philadelphia, Pa.



Expansion joint with extension guide

Improved Commutator Grinders

A NUMBER OF IMPORTANT CHANGES have recently been made to the "Perfect" and "Ideal" models of precision commutator grinders put out by the Ideal Commutator Dresser Company, Sycamore, Ill.



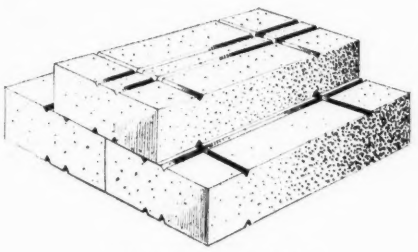
Improved "Perfect" and "Ideal" model precision grinders

In the "Perfect" model grinder shown in the upper view the location of the cross-feed screw has been changed from the center to the back of the bedplate. The head now rides on a solid plate instead of rails and stone tools are held by one plate instead of two clamps as formerly used. The cross-feed handle of the lathe type has been substituted for one of the wheel type.

Somewhat similar changes have been made to the "Ideal" model grinder shown in the lower view. The rack has been placed at the back of the bedplate and a solid plate is now used in place of the rails. The general arrangement of the cross and rack feeds has been changed and star kinds are now used on both feeds.

Grooved Firebrick in Furnace-Wall Construction

As a result of six years' experimental and service testing the Power Plant Efficiency Company, Indianapolis, Ind., is now producing RL-Right-Lock firebrick for boiler-furnace walls and for any service requiring standard firebrick. These bricks are grooved as indicated in the accompanying illustration. Bonding material in the corresponding grooves of adjoining brick lock the various rows horizontally and parallel to the hot wall face. This construction provides a flexible wall that tends to expand and contract in a straight line and by so doing eliminate wall bulging and the rapid deterioration usually resulting. "Right-Lock" brick are of standard firebrick size, and only one style is needed for both header and stretcher courses.



"Right-Lock" firebrick

Improved Automatic Lubricating System

In the "Dualine" system of lubrication described in the Nov. 11, 1930, number, two power-driven pumps were used, one to charge the valves at each bearing with grease and the other to supply the necessary oil pressure to force the grease into the bearings.

Since this description appeared a number of changes and improvements have been made to the system. One central pump is now used in place of two, and the controls have been greatly simplified. This single pumping unit supplies lubricants at high pressure to both supply lines throughout the entire system.

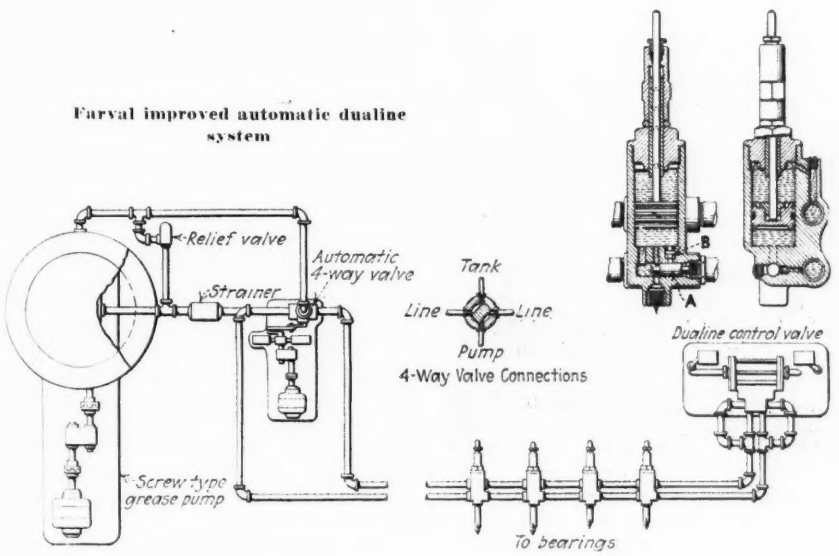
The delivery of lubricant to one supply line loads all the valves with a measured quantity and the delivery of grease to the other supply line discharges the measured quantity from each valve into its bearing at high pressure. The delivery of lubricant to both of the supply lines is controlled by a four-way, hydraulic reversing valve which may be either electrically or manually operated.

The type of valve used at each bearing is essentially the same as previously described except that the body is forged with a double-tee section making the valve body itself part of the piping system. An indicating rod has also been attached to the primary piston to give a visible indication of the valve's operation.

Referring to the cross-section of the valves, when pressure is applied to the charging line, the small piston *A* is moved back to uncover the inlet port to the valve cylinder and cover the discharge port. As the cylinder fills with grease, the piston is pushed to the top. In this position, pressure applied to the shooting line, through operation of the four-way valve, enters the valve cylinder above the piston, forces the piston downward and discharges the grease to the bearings. As the piston starts downward check valve *B* closes and piston valve *A* moves to the right, closing the inlet and allowing the lubricant to flow out as indicated by the arrows.

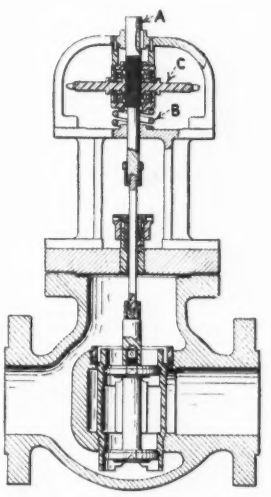
When the four-way reversing valve is electrically operated, the operation of the motor is controlled by means of an electric clock and the frequency of the cycle of operation can be at an interval from two minutes to two hours. The final shutoff of the central pumping unit is accomplished through the control valve located at the end of the line, as shown in the illustration. The system is manufactured by Lubrication Devices, Inc., Battle Creek, Mich.

Farval improved automatic dualine system



Control Valve Gives Straight-Line Flow Characteristic

The illustration shows the improved Type K control valve put out by the Bailey Meter Company, Cleveland, Ohio, for use with its automatic control systems and with practically any liquid.



Section of style K control valve

The design of the valve is such that it can be placed in a vertical or horizontal pipe. It is fully balanced and fitted with V-ports designed to give a straight-line flow characteristic. The valve cage is of one-piece construction, but provision is made in the method of fastening it in the valve body to take care of difference in expansion and contraction.

The valve is opened by pressure applied to the stem *A* by a hydraulically operated sylphon unit (not shown) and closed by spring *B*. Tension on the spring is regulated by the handwheel *C* fitted with a ball bearing on each side to take the thrust in either direction and permit ready adjustment of the tension with the valve in service.

NEWS of the FIELD

Iron and Steel Electrical Engineers Hold Convention and Exposition in Cleveland

Motor drives, a.-c. arc welding, lubrication, wire rope, and heavy a.-c. conductors, among topics covered at meeting

LAST WEEK at the Public Auditorium in Cleveland Ohio, the Association of Iron and Steel Electrical Engineers held its 27th annual convention. As in previous years the association's iron and steel exposition was an outstanding feature of the convention. Nearly 150 manufactures exhibited equipment and materials used in the generation, distribution and application of power to the production of iron and steel. An added feature of this year's convention was the meetings of the Wire Association, which were also held in the Public Auditorium. This gave the iron-and-steel electrical engineers interested in wire and wire-rope problems an opportunity to attend these meetings.

An inspection trip of special interest was held on Friday, to the Goodyear Tire & Rubber Company plant in Akron. The two power houses in this plant have a total capacity of 55,000 kva., supplied with steam from boilers aggregating 288,000 sq.ft. of heating surface and fired by pulverized coal. Power is transmitted at 2,300 volts and the connected motor load totals 84,000 hp. On this trip the world's largest airship, "The Akron," being built by the Goodyear Zeppelin Corporation, was visited and Lieutenant-Commander C. E. Rosendahl, described many interesting engineering features of the ship. This ship has eight engines that develop a total of 4,480 hp., compared to 2,000 hp. for the five engines in the "Los Angeles."

Electrical Development

Among the features of the seven technical sessions was the report of the electrical development committee, W. H. Burr chairman. This report states that although many industries experienced unfavorable conditions during 1930 the steel industry was especially active in electrical developments. Of the 109 main-roll-drive motors, of over 300 hp. capacity, installed during the year, 70 were of the direct-current type. This is considered as an indication that direct-current motors are more suitable for most applications of this type than alternating-current types.

It is only a few years ago that synchronous motors had no place as steel-mill drives. The use of these motors in this service is now increasing rapidly and last year five were purchased with an aggregate rating of 16,500 hp. A 3,000-hp., 11,000-volt, 100-r.p.m., 60-cycle synchronous motor was put into operation, designed to start on full voltage by connecting directly to the 11,000-volt line. Synchronous motors are being installed to maintain a good power factor in order to obtain a low rate for purchased power and because of the gain in efficiency.

The conclusions given in a paper on "Research Covering Alternating-Current Arc Welding," by Grover A. Hughes and R. C. McBride, are that:

A.-C. Arc Welding

Alternating current for arc welding is satisfactory as to tensile strength, ductility, rate of depositing metal and current consumption. Efficiency of welder is high and voltage and current curves are ideal. Satisfactory welds can be made with bare electrodes. Satisfactory welds can be made with non-ferrous metals. Alternating current is not superior to direct current, but alternating-current arc welders are as practical and have their place in industry.

A report by the Committee on Bearings, F. D. Egan, Chairman, gave some interesting observations on the lubrication of bearings. An abstract of this report appears on page 1003 of this number.

A whole day was devoted to a syymposium on lubrication. A report was presented by the association's committee on lubricating engineering. Other subjects included in this symposium were two papers on testing lubricants, one by Frank L. Gray and another by E. S. Glauch; "Crane Lubrication," by T. J. Flaherty; "Lubrication of Electrical Apparatus Used in Steel Mills," by J. L. Brown; "Lubrication of Turbine Generators," by James L. Roberts; and "Lubrication of Machine Tools," by J. H. Van Campen. An abstract of Mr. Gray's paper on "Testing of Lubricants" will appear in an early number.

"Conductors of Heavy Alternating-Current" was the subject of a paper by D. I. Bohn and H. W. Pabst, which discussed the carrying capacity of the conventional-type laminated-copper busbars and of tubular copper and aluminum conductors. The characteristics of these were compared with a new type of bus construction made of aluminum channels. Each busbar consists of two channels placed so as to form a split hollow square. For a given weight of metal, this construction has a carrying capacity equivalent to a tubular conductor. Several installations of this type have been made in industrial plants and power houses. An abstract of this paper will appear in an early number.

So. Calif. Edison Company May Adopt Mercury Unit

Executives of the Southern California Edison Company, are studying the progress being made with the mercury-vapor turbine being developed by the General Electric Company at Schenectady, N. Y., with the view of adopting this turbine in connection with the next 133,000-hp. unit to be installed at the Edison company's Long Beach steam-electric generating station. Announcement of the company's consideration of the mercury turbine equipment was made recently by Fred B. Lewis, vice-president and assistant general manager of the Edison company at Los Angeles, Calif.

Appalachian Company Files Suit in New River Case

Suit has been instituted in the Federal District Court at Lynchburg, Va., by the Appalachian Electric Power Company against the Federal Power Commission, in which the Virginia corporation is asking the court to declare unconstitutional a portion of the act creating the board, which gives it the right to take jurisdiction of headwaters of navigable streams.

Involved in the issue is the effort of the company to construct an $11,000,000 power project on New River, near Radford, Va. The bill recites that the commission authorized issuance of a major license to the power company, which would be limited to 50 years, and which the company has declined to accept.

The company recites the fact in its

bill that it was ordered by the commission on April 3, 1931, not to proceed with the construction, the commission asking for a court decision as to the importance of questions of jurisdiction between the United States and the State of Virginia.

Utilities Fight Power Tax in South Carolina

A TEMPORARY RESTRAINT has been granted by Judge Ernest F. Cochran in the United States District Court for the eastern district of South Carolina against collection of levy under the recently enacted power excise tax on electric utilities in that state.

The new law provides for a levy of one-half mill per kilowatt-hour on all electrical energy generated within the State. A petition for injunction was presented to the Federal court by the Broad River Power Company, the Lexington Water Power Company and the South Carolina Power Company, in which it was alleged that the tax violates both the State and the Federal Constitutions.

Judge Cochran granted a temporary restraining order against the State Tax Commission. No date has been fixed for hearing upon the question of making the injunction permanent.

Fuel Association to Meet in September

THE ANNUAL MEETING of the International Railway Fuel Association, usually held in May, has been postponed this year until the third week in September, when a two-day business session will be held, without exhibition or entertainment features. The decision to hold this meeting, which is scheduled for Sept. 15 and 16 at the Hotel Sherman, Chicago, Ill., was made at a recent meeting of the executive committee of the association at Cincinnati, Ohio.

It was the conclusion of the committee that economies in the purchase, handling and use of railway fuel are of more than ordinary importance at the present time, that the International Railway Fuel Association has, in the past, contributed substantially to fuel conservation progress on the railroads, and that to forego the annual meeting of the association this year would be not only to lose much ground already gained at a large expenditure of time and effort, but to overlook an opportunity for still further reductions in operating expense by the more efficient handling and use of fuel. In deference to present reduced business activity and the urgent necessity for economy, it was decided to cut the annual convention from four days to two days and limit the addresses and committee reports strictly to those having a direct bearing on fuel performance, as reflected in increased railway operating efficiency.

V.D.I. 75th Anniversary Celebration Starts This Week; 72 A.S.M.E. Members to Attend

CELEBRATION of the 75th anniversary of Germany's largest engineering society, the Verein Deutscher Ingenieure, will start this week with the opening of the society's 70th annual meeting at Cologne on Friday, June 26. The meeting will continue through Monday, June 29, with appropriate ceremonies, historical papers, technical sessions and inspection trips.

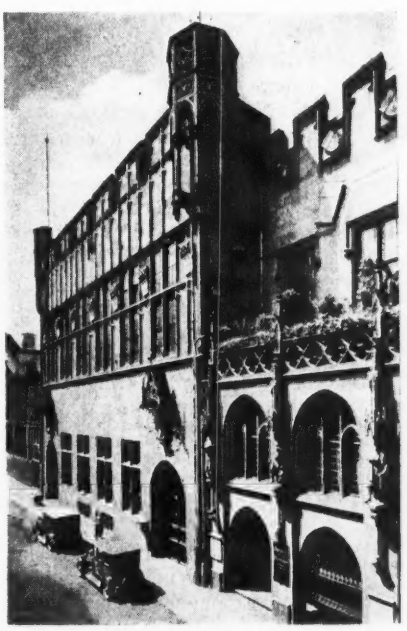
Seventy-two members of the American Society of Mechanical Engineers and their families, who sailed from New York, June 13, on the society's European tour, will be present at the celebration. Calvin W. Rice, secretary of the A.S.M.E., has been designated as the official representative of the American society at the anniversary meeting, which is the principal feature of the A.S.M.E. European tour. This tour, lasting until Aug. 5, will cover many points of technical and scenic interest in England, Germany, Italy and France.

The V.D.I. celebration will open with an exposition on the history of the society, followed by the unveiling of a memorial to Langen and Otto, inventors of the gas engine. During the four-day meeting many interesting papers will be given on the history of science and invention. The technical session will be devoted to discussions of combustion, steam and hydraulic turbines, welding of boilers and pipe lines, flow research, internal-combustion engines, lignite mining, transportation, protective coatings, light metals and engineering education.

Papers to be presented at the session on combustion include "Physics of Combustion of Solid Fuels," Dr. Ing. Rosin; "Flexibility of Stoker Firing," Dipl.-Ing. Schulte; and "Experiments in the Combustion of Pulverized Coal," Dipl.-Ing. Werkmeister.

At the session on welding, the following papers will be read and discussed: "Stress Distribution in Welds According to Föppl's Law, Especially in Boilers and Pressure Vessels," Dipl.-Ing. Kochendörffer; "Welding of High-Pressure Shells and Tanks in Application to Steam-Boiler Construction," Ob.-Ing. Jurczyk; "The Manufacture of Heavy-Duty Steam-Boiler Parts With Water-Gas Welding," Dir. Wallman; and "Investigation of the Welding Characteristics of High-Carbon Steel," Dipl.-Ing. Stursberg.

Among the papers to be given at the session on steam and hydraulic turbines are "Flow in Hydraulic Turbines," Dr. Ing. Föttinger; "High-Speed Hydraulic Turbines," Dr.-Ing. Hahn; and "Flow in Steam Turbines," Dir. Hofer.



The old Guerzenich Building in Cologne, where the 75th anniversary celebration of the V.D.I. will be held on June 26 to 28

Committee Appointed to Investigate Beauharnois

FOLLOWING closely upon the demand made by Robert Gardiner, Progressive leader in the Canadian House of Commons for an investigation of the Beauharnois power project, Premier Bennett has announced the appointment of a parliamentary committee to go into the entire situation from the time of the inception of the scheme. The committee will be under the chairmanship of Hon. W. A. Gordon, minister of immigration and colonization, and Mr. Gardiner will be a member of the investigating body.

N.E.L.A. Awards Made; Kehoe Heads Engineering

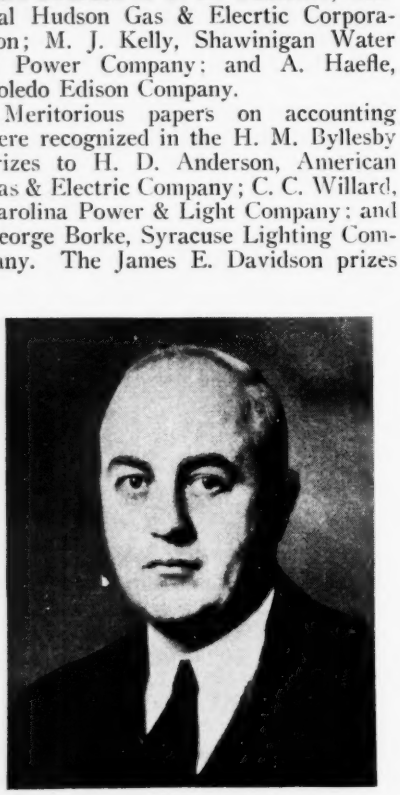
ANNUAL AWARDS for outstanding ideas and service in the electric utility field were made to fifteen companies and individuals at the recent convention of the National Electric Light Association.

The Charles A. Coffin award for the company with the best record of achievement during 1930 was made to the Virginia Electric & Power Company. Another Virginia utility, the Virginia Public Service Company, won the B. C. Forbes cup for the most constructive public relations campaign, and the James M. Gilchrist award went to Indianapolis Power & Light Company.

Awards to individuals included the Henry L. Doherty prize to A. F. Tegen, Milwaukee Electric Railway & Light company; the Martin J. Insull prize to Daniel Ravenal, Jr., South Carolina Power Company; and the Augustus D. Curtis award to M. F. Cushing, New Orleans Public Service, Inc. The

James H. McGraw prizes for the best engineering papers submitted in 1930 were awarded to G. H. Underhill, Central Hudson Gas & Elecrtic Corporation; M. J. Kelly, Shawinigan Water & Power Company; and A. Haefle, Toledo Edison Company.

Meritorious papers on accounting were recognized in the H. M. Byllesby prizes to H. D. Anderson, American Gas & Electric Company; C. C. Willard, Carolina Power & Light Company; and George Borke, Syracuse Lighting Company. The James E. Davidson prizes



Arthur H. Kehoe

for exceptional papers on merchandising were presented to L. G. Cannon, Commonwealth Edison Company; H. M. Stark, Electric Bond & Share Company; and D. F. Conger, New York Light & Power Corporation.

At the close of the engineering section session of the convention, the following officers were chosen to head the section for the coming year: Chairman, A. H. Kehoe, electrical engineer, United Electric Light & Power Company, New York; vice-chairman, Mark Eldredge, chief engineer, Memphis Power & Light Company; members-at-large, A. E. Silver, C. C. Post, A. D. Bailey, C. M. Allen, R. F. Danner, H. L. Wills, F. R. George, N. E. Funk and W. G. Kelley.

Municipal Steam Plant Finished at Eugene, Ore.

THE NEW steam stand-by plant of the city of Eugene, Ore., municipal system was completed ready for service and tested during the first week in June. The plant, which is to serve for breakdown service only, taking the place of a stand-by agreement with the Mountain States Power Company, of Albany, contains a 14,130-sq.ft. Erie boiler, operating at 250 lb. pressure and 200 deg. F. superheat, and a 6,000-kw., 11,000-volt, G.E. turbine-generator. Oil will be used for fuel. The building is of concrete with a temporary tile wall in one end to provide for possible future extension.

COMING CONVENTIONS

American Society of Mechanical Engineers. National Oil and Gas Power Meeting at the University of Wisconsin, Madison, Wis., June 23-26. Secretary, Calvin Rice, 33 West 39th St., New York City.

American Institute of Electrical Engineer. District meeting at Lake Tahoe, Calif., Aug. 25-28. District meeting at Kansas City, Mo., Oct. 22-24. Secretary, F. L. Hutchinson, 33 West 39th St., New York.

Association of Edison Illuminating Companies. Forty-seventh annual meeting at The Greenbrier, White Sulphur Springs, W. Va., Sept. 21-25. Secretary, Preston S. Millar, 80th St. and East End Ave., New York City.

International Railway Fuel Association. Annual convention at the Hotel Sherman, Chicago, Ill., Sept. 15-16. Secretary, C. T. Winkless, Room 700, La Salle Street Station, Chicago, Ill.

National Association of Power Engineers. Annual convention and mechanical exposition in the Convention Hall, Kansas City, Mo., Sept. 7-11. Secretary, Fred W. Raven, 417 South Dearborn St., Chicago.

Smoke Prevention Association. Annual meeting at the Hotel Pantlind, Grand Rapids, Mich., June 30-July 3. Secretary, Frank A. Chambers, City Hall, Chicago, Ill.

Third International Conference on Bituminous Coal. At Carnegie Institute of Technology, Pittsburgh, Pa., Nov. 16-21. Chairman, Thomas S. Baker, president of Carnegie Institute of Technology.

Universal Craftsmen Council of Engineers. Annual convention at the Sherman Hotel, Chicago, Ill., Aug. 4-8. Secretary of Convention Committee, James J. Blaine, 7342 Harvard Ave., Chicago, Ill.

Excavation Completed for Hydraulic Laboratory

STEADY PROGRESS is being made in the construction of the National Hydraulic Laboratory, according to a recent announcement of George K. Burgess, director of the Bureau of Standards. The main contract was let in April to Stofflet & Tillotson of Philadelphia for $294,887, and work began April 26 and should be finished next March. The steam-shovel excavation is completed, and the concrete footings of the measuring basin are being poured. Hand excavation for the remaining footings is now under way. Orders have already been placed for the piping, sluice gates, heat and power ducts, pumps and for the main switchboard.

In view of the fact that hydraulic research cannot be undertaken until the building is completed and equipped as fully as funds will permit, it has been decided to postpone the selection of the head of the laboratory for the present and to devote all available funds to equipment, Dr. Burgess announced.

Personals

WILLIAM VON PHUL, president of Ford, Bacon & Davis, Inc., engineers of New York City, received on June 9 the first honorary degree of Doctor of Engineering conferred by Tulane University, in New Orleans. An internationally known engineer, Dr. von Phul was graduated from Tulane in 1893 with the university's first degree in mechanical engineering.

HON. J. R. COOKE, member of the Ontario Legislature, has been appointed chairman of the Hydro-Electric Power Commission of Ontario to succeed C. A. MAGRATH, who resigned some time ago to devote his entire attention to the activities of the International Boundaries Commission. Mr. Cooke has served the power commission in various capacities for the last eleven years. It is understood that C. A. MAGUIRE, of Toronto, will be promoted to vice-chairman of the power commission.

HENRY GRENACHER, for the past six years in charge of the operating department of the Northern States Power Company, Minneapolis, has been elected vice-president in charge of operation of that company. Previous to his connection with the Northern States company, Mr. Grenacher was assistant to HALFORD ERICKSON, vice-president in charge of operation of the Byllesby Engineering & Management Corporation.

H. R. MYERS, chief engineer of Hungerford & Terry, Inc., of Clayton, N. J., for the past six years, has been placed in charge of the company's Boston office, succeeding D. R. WEEDON, who has resigned.

JOHN A. DARLING, assistant chief system operator of the Edison Electric Illuminating Company of Boston, has been elected chairman of the System Operators' Association of New England. Mr. Darling has been with the Boston Edison company for more than 30 years.

MURRAY G. DAY, formerly superintendent of power of the New Bedford Gas & Edison Light Company, New Bedford, Mass., has become associated with the Dampney Company of America, Hyde Park, Boston. He will be attached to the Chicago branch office, it is stated.

L. V. NELSON has been appointed power supervisor of the Union Electric Light & Power Company, of St. Louis.

GORDON FOX and W. S. ORR, members of the engineering staff of the Freyn Engineering Company, arrived in this country on June 19 from Russia, where they have spent the past ten months in connection with consultation services which the company is rendering to the Soviet iron and steel industry.

Business Notes

FISHER GOVERNOR COMPANY, Marshalltown, Ia., is celebrating the fiftieth anniversary of its establishment. An attractively illustrated booklet is being issued, which gives a brief history of the company and describes its present plant facilities. In keeping with its steady growth, the company announces the opening of a new branch factory in Los Angeles, Calif., under the direct supervision of Jasper H. Fisher, chairman of the board; Ray McCoy, factory manager, who for the past eighteen years has been an inspector in the Marshalltown factory; and Forest Wehrman, in charge of the office and accounting department.

MODERN COAL BURNER COMPANY, Chicago, Ill., announces the opening of a direct factory branch at 4450 Duncan Ave., St. Louis, Mo., with E. S. Bremerman in charge as district manager. In addition to metropolitan St. Louis, the new branch will serve the southern and eastern sections of the state.

CLARAGE FAN COMPANY, Kalamazoo, Mich., announces the appointment of Charles R. McConner as sales manager. Mr. McConner has been associated with the company since 1920, serving as branch manager in both Chicago and Detroit.

ROMEC PUMP COMPANY is the new corporate name of the MARTELL PACKINGS COMPANY, of Elyria, Ohio. The change was made, it is stated, to establish a closer relationship between the company's name and its product, the "Romec" pump.

RILEY STOKER CORPORATION, Worcester, Mass., announces the appointment of Arthur T. Hunter as assistant sales manager of the boiler division. Mr. Hunter has been engaged in power-plant engineering and sales work at St. Louis, Mo., since 1923.

NEILAN COMPANY, LTD., Los Angeles, Calif., announces the opening of a branch office at 1301 Clark Building, Pittsburgh, Pa. Bruce Irwin, sales engineer of wide experience in plant design, has been appointed manager in charge of this new office.

CLAUD S. GORDON COMPANY, Chicago, Ill., announces that George F. Newell has been elected vice-president and general manager of its subsidiary, the Pyrometer Service & Supply Corporation, 1988 East 66th St., Cleveland, Ohio. Mr. Newell was formerly the Chicago representative of CHARLES ENGELHARD, INC., Newark, N. J.

NORTHERN EQUIPMENT COMPANY, Erie, Pa., announces the appointment of Joseph W. Eshelman as its representative in eastern Tennessee. This is an extension of the territory formerly served by Mr. Eshelman from his offices in the Webb-Crawford Building, Birmingham, Ala., it is stated.

How's Business?

SUMMER SETS in without any sign that business is going to break through the bottom on which it has been stabilizing itself for six months, according to the *Business Week* forecast of June 24. The seasonal let down in the general level of activity seems, on the whole, to be little, if any, more than usual so far, and in some respects slow improvement since the beginning of the year has become evident.

The production of electricity by public utilities in the United States for the week ended Saturday, June 13, was 1,581,220,000 kw.-hr., according to the National Electric Light Association. This is 4.9 per cent below the corresponding period in 1930. The Atlantic seaboard shows a marked decline in electrical output from last year, registering a decrease of 1.4 per cent. The great central industrial region, outlined by Buffalo, Pittsburgh, Cincinnati, St. Louis and Milwaukee, registers, as a whole, a decrease of 8.3 per cent, although some relative improvement from previous weeks is indicated in the Chicago area. The Pacific Coast shows a drop to 6 per cent below last year.

Trade Catalogs

INSTRUMENTS—A compact, illustrated catalog, entitled "Bacharach Instruments for Use in Engineering Schools," has recently been issued by the Bacharach Industrial Instrument Company, 7000-6 Bennett St., Homewood Station, Pittsburgh, Pa. Besides late developments in the company's line of "Maihak" engine indicators, it covers pyrometers, CO_2 meters, flow meters, manometers, inclined gages and special equipment for college use.

PUMPS—Details of the design, construction and installation of Type S single-stage, split-casing pumps are given in Bulletin No. 315, recently issued by the Byron Jackson Company, 6th and Carlton Sts., Berkeley, Calif. In addition to tables of engineering data, there are many illustrations of actual installations.

GENERATORS AND MOTORS—Circular 1908, a new publication of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., entitled "Small Generator Units and their Aplications," describes and illustrates belt-driven generators, turbine-generator units, portable gas-engine generators and electric service plants in capacities up to 15 kw. Recent modifications in the construction of Type EVS water-wheel generators are presented in Leaflet 20452-A, and the new Type CS W-frame squirrel-cage induction motors, which have interchangeable mechanical and electrical parts, are described in Leaflet 20385-A.

DIESEL-ENGINE SILENCERS—Maxim silencers for diesel-engine exhausts and intakes are described and illustrated in a recent folder issued by the Maxim Silencer Company, Hartford, Conn.

VIBRATION ELIMINATION—"How to Deaden Machine Vibrations and Noise" is the title of a new bulletin just published by L. Mundet & Son, 461 Eighth Ave., New York City, which explains how machinery should be isolated by means of natural cork so that noise and vibration will be eliminated.

▼

Fuel Prices

FUEL OIL

Boston—June 15, tank-car lots, f.o.b. 12@14 deg. Baumé, 2.9c. per gal.; 28@32 deg., 4.83c. per gal.

New York—June 18, f.o.b. Bayonne, N. J., 28@34 deg. Baumé, industrial use, tank-car lots, 4.5c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 6c. per gal.

Philadelphia—June 16, No. 3, industrial gas oil, $1.83 per bbl.; No. 4, light industrial fuel oil, $1.31 per bbl.; No. 5, medium industrial fuel oil, $1.20 per bbl.; No. 6, heavy (Bunker C), $1.05 per bbl.

Pittsburgh—June 9, f.o.b. local refinery, fuel oil, 30@34 deg., 2.5c.@2.625c. per gal.; 36@40 deg., 2.5c.@2.625c. per gal.

Cincinnati—June 16, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 4.5c. per gal.; 26@30 deg., 4.75c. per gal.; 30@32 deg., 5c. per gal.

Chicago—June 12, tank-car lots, f.o.b. Oklahoma; freight to Chicago, 90c. per bbl. or 42 gal.; 18@22 deg., 30c. per bbl.; 22@24 deg., 35c. per bbl.; 24@26 deg., 40c. per bbl.; 26@28 deg., 47.5c. per bbl.; 28@30 deg., 55c. per bbl.

St. Louis—June 16, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.095 per bbl., or 42 gal.; 26@28 deg., $1.17 per bbl.; 28@30 deg., $1.245 per bbl.; 30@32 deg., $1.345 per bbl.; 32@36 deg., gas oil, 2.526c. per gal.; 38@40 deg., distillate, 3.151c. per gal.

Dallas—June 13, f.o.b. local refinery 24@26 deg., 90c. per bbl. or 42 gallons.

COAL

Bituminous (Net Tons)	At Mine, for Shipment to	Price per Ton
Pool 9, super low-vol.	New York	$1.75 @$1.85
Pool 10, h. gr. low-vol.	New York	1.50 @ 1.65
Pool 11, low-vol.	New York	1.40 @ 1.50
Smokeless, mine-run	Chicago	1.50 @ 1.75
Smokeless, slack	Chicago	.60 @ 1.10
Harlan, Ky., slack	Chicago	1.10 @ 1.20
Franklin, Ill., mine-run	Chicago	2.15
Franklin, Ill., screen	Chicago	1.50 @ 1.75
Ind. 5th Vein, m.-r.	Chicago	1.20 @ 1.75
Standard Ill., mine-run	St. Louis	1.25 @ 1.40
W. Ky., mine-run	Louisville	.85 @ 1.25
W. Ky., slack	Louisville	.60 @ .85
Pittsburgh, mine-run	Pittsburgh	1.35 @ 1.45
Smokeless, mine-run	Cincinnati	1.60 @ 1.75
Smokeless, slack	Cincinnati	.70 @ 1.25
Kanawha, mine-run	Cincinnati	.90 @ 1.25
Kanawha, nut-slack	Cincinnati	.50 @ 1.00

Anthracite (Net Tons)	At Mine, for Shipment to	Price per Ton
Buckwheat	New York	$3.10 @$3.25
Barley	New York	1.00 @ 1.40

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Calif., San Jose—City, H. Pfister, Co. Clk., will soon award contract for furnishing and installing an ice making and refrigerating plant for service building at County Hospital.

Conn., Hartford—Bd. of Contract & Supply, will soon award contract for the construction of a pumping station in connection with dike project at South Meadows. Estimated cost to exceed $25,000. R. N. Clark, City Hall, is engineer.

Ill., Chicago — Graham, Anderson, Probst & White, 80 East Jackson Blvd., will receive bids until July 7 for the construction of a 43 story stores and office building at LaSalle, Adams and Clark Sts., for Marshall Field Estate, 232 South Clark St. Estimated cost $12,000,000.

Ind., Greensburg—Odd Fellows Home, will build a new heating plant. Estimated cost $40,000. C. E. Bacon, 606 Odd Fellows Bldg., Inianapolis, is architect. Work will be done by separate contracts.

Ia., Burlington—Citizens Water Co., F. D. Lawler, Supt., awarded contract for completion of 15 x 18 ft. pumping station to Andy Danielson & Son, Burlington.

Mass., Boylston — Worcester County Tuberculosis Hospital, E. W. Glidden, Court House, awarded contract for the construction of a sanitorium, nurses' home and power house at Huntington Farm to Wiley & Foss, Central and Brooks St., Fitchburg. $956,655.

Mass., Cambridge (Boston P. O.)—City plans waterworks improvements including extensions to Stoney Brook reservoir, large distribution mains, motors, filter beds, etc. Estimated total cost $850,000. Hazen & Everett, 25 West 43rd St., New York, N. Y., are engineers. Maturity indefinite.

Mass., Wrentham—Dept. of Mental Diseases, is having sketches made for the construction of a 3 story employees' building and heating plant at Wrentham State School. Estimated cost $150,000. J. H. Ritchie & Associates, 250 Stuart St., Boston, are architects.

Mich., Detroit—Public Lighting Commission, East Atwater St., awarded contract for the construction of railway substation No. 38 at Joseph Campau and Davison Aves. to Misch Bros., Inc., 3005 Gratiot Ave. Estimated cost $25,000.

Minn., Moorhead—Commission of Administration & Finance, Capitol, St. Paul, will receive bids until June 30, for the construction of a 3 story main recitation and physical education building, 3 story, demonstration school and 82 x 260 ft. central heating plant at State Teachers College here. Estimated total cost $765,000. C. H. Johnston, 360 Robert St., St. Paul, is architect.

Minn., St. Paul—City and Ramsay County, G. Bundlie, Chn. of Building Commission, awarded contract for the construction of a city hall and court house at Third, Wabash, Fourth and St. Peter Sts. to Foley Bros., 209 Gilfillan Blk., plumbing and heating to Healy Plumbing & Heating Co., 278 West 4th St. Estimated total cost $3,000,000.

N. H., Berlin—Coos Gas Co., O. J. Coulombe, Pres., plans the construction of a gas manufacturing plant. Estimated cost $40,000. Engineer not selected.

N. J., Elizabeth—Consolidated Gas Co., 16 West Jersey St., is having preliminary plans prepared for the construction of a 50 x 75 ft. power plant and boiler room at Erie St. and Third Ave. Estimated cost $40,000. Private plans.

N. J., Newark—New Jersey Toilet & Towel Supply Co., 69 New St., will soon award contract for alterations to laundry and power plant, also purchase of equipment and machinery at 42 Clifton St. Estimated cost including equipment $180,000.

N. J., Paterson—Passaic Valley Water Commission, J. Wilson, Pres., 156 Ellison St., will receive bids until June 30 for dismantling and removing two Holly pumping units, four Reidler pumping units, four Francis water turbines and penstocks; two steam turbine centrifugal pumping units and miscellaneous small engines and machinery.

N. Y., Rockaway Point (sta. Brooklyn) — Rockaway Operating Co., 421 7th Ave., New York, plans the construction of a 48 x 48 ft. pumping station and equipment at Roxbury, Rockaway Point. Estimated cost to exceed $15,000.

N. Y., Warwick — Commissioners of Social Welfare, State Office Bldg., will receive bids until July 15 for the construction, heating, and electric work for twenty-five buildings and service connections at New York State Training School for Boys here.

O., Martins Ferry—City awarded contract for a turbine and generator to Westinghouse Electric & Mfg. Co., Grant Bldg., Pittsburgh, Pa. $53,600.

Pa., Erie—Hamot Hospital, F. W. Brouitt, Acting Dir., 4 East Second St., had plans prepared for a 6 story hospital and nurses' home. Estimated total cost $1,250,000. Crow, Lewis & Wick, 200 5th Ave., New York, N. Y. Maturity late 1932.

S. D., Aberdeen—State of South Dakota, J. Berg, State Engr., Pierre, will soon receive bids for the construction of a 40 x 70 ft. central heating plant at Northern State Normal and Industrial School. Estimated cost $100,000. G. F. Fossum, Aberdeen, is architect. C. Foster, 512 Sellwood Bldg., Duluth, Minn., is engineer.

S. D., Brookings—State College, C. W. Pugsley, Pres., will receive bids until July 7, for addition to present power plant, furnishing and installing 450 hp. boiler, smoke breeching, stoker, draft fans, etc. F. C. W. Kuehn, Huron, is engineer.

Tex., Alpine—Central Power & Light Co., Alamo Bank Bldg., San Antonio, awarded contract for addition to ice plant including platforms, installation of additional ice-making machinery, etc. here to Sumner Sollitt Co., National Bank of Commerce Bldg., San Antonio. $35,000.

Tex., Eagle Lake — Central Power & Light Co., Alamo Bank Bldg., San Antonio, awarded contract for the construction of a large ice storage vault, additions and alterations to ice and power plants; some new ice equipment and new unit for light plant, and line extensions to E. H. Reese, Eagle Lake. Estimated cost $40,000.

Va., Langley Field — Constructing Quartermaster, will soon award contract for the construction of eleven air corps hangars, boiler houses, etc., will also receive bids until July 14 for heating plant and barracks buildings. Estimated cost $1,750,000 and $100,000 respectively.

Wis., Grafton—City, R. P. Zoun, Clk., will soon award contract for a sewage treatment plant including pump house, pumping equipment, motors, etc. P. Clark, Appleton, is engineer.

B. C., Vancouver — Vancouver Ice & Cold Storage Co. Ltd., 11 Yore Ave., awarded contract for a 45 x 76 ft. addition to cold storage warehouse to Smith Bros. & Wilson, Ltd., 1267 Richard St. Estimated cost $45,000.

Panama—H. Burgess, Governor, Panama Canal, Munitions Bldg., Washington, D. C., will receive bids until Sept. 1 for the construction of Madden dam, power plant and appurtenant works for Madden dam project near Alhajuela on upper Chargres River.

Equipment Wanted

Pumping Unit—Overton, Tex.—City plans to purchase pumping unit in connection with proposed waterworks and distribution systems. Estimated cost $40,000.

Pumps—Calexico, Calif.—City Council is receiving bids for a 1,000 g.p.m. booster pump with 40 hp. electric motor for waterworks department.

Pumps, Motors, Press Filters, etc. — Cairo, Egypt—Dept. of Public Works, will receive bids until Aug. 1 for supply and erection of pumps, motors, press filters, settling tanks, water distribution pumps and accessories at Edfu power station.

Industrial Projects

Del., Wilmington—Ethyl Gasoline Corp., 135 East 42nd St., and Dow Chemical Co., 60 East 42nd St., New York, N. Y., plans the construction of a plant for extraction of bromides from sea water here. Estimated cost to exceed $5,000,000.

Ind., Anderson — Guide Lamp Co., awarded contract for a 2 story, 40 x 100 ft. factory on West 25th St. Estimated cost $40,000. Work will be done by separate contracts.

Ind., Terre Haute—Highland Iron & Steel Co., 28th St. and 4th Ave., subsidiary of American Chain & Steel Co., 400 West Madison Ave., Chicago, Ill., plans the construction of a new unit to plant here. J. Schlossberg, is plant manager.

Ky., Owensboro—Owner, c/o W. W. Tapp, Jr., Starks Bldg., Louisville, plans the construction of an oil refinery, 20,000 bbl. of crude oil, daily capacity here. Estimated cost $110,000. Engineer not definitely determined.

Mass., Everett (Boston P. O.) — Merrimac Chemical Co., Chemical Lane, will soon award contract for the construction of an alum process building including concrete tanks. Estimated cost $40,000. Private plans.

Mass., Hyde Park (sta. Boston) — Royal Curtain Mfg. Co., 35 Kingston St., Boston, taking preliminary estimates for alterations to factory on Hyde Park Ave. here. Estimated cost $40,000. Private plans.

Mass., West Chelmsford—H. E. Fletcher Co., will build a 1 story, 75 x 120 ft. granite cutting plant including 200 ft. craneway, power lines, air lines, etc. Estimated cost $100,000. Work will be done under the supervision of L. F. Caproni & Co., 1044 Chapel St., New Haven, Conn., Consult. Engrs.

Mich., St. Clair — Buhl Aircraft Co., Marysville, is having plans prepared for the construction of a 1 and 2 story airplane factory at St. Clair Airport. Estimated cost $100,000. Private plans. Electric motors, etc., will be installed.

N. J., Allwood—American Colortype Co., 207 West 25th St., New York, N. Y., will soon award contract for alterations to plant here. Estimated cost $40,000. Ballinger Co., 12th and Chestnut Sts., Philadelphia, Pa., is architect and engineer. Contract for road work let.

N. J., East Rutherford — East Rutherford Syringe Co., 75 Mozart St., postponed construction of 2 story, 30 x 70 ft. factory at 54 Mozart St. Estimated cost $40,000. J. T. Camlet, 26 Piaget Ave., Clifton, Archt. Maturity probably in September.

N. J., Maplewood—Kroydon Co., Burnet Ave., is receiving bids for a 1 story addition to factory for the manufacture of golf clubs. Estimated cost $40,000. D. A. Hopper, 22 Ridgewood Ave., Irvington, is architect.

N. J., Newark — John C. Kohaut, Inc., 117 Green St., awarded contract for the construction of a 3 story, 50 x 100 ft. woodworking factory on New York Ave. to Pellecchia Construction Co., 50 Branford Pl. Estimated cost $40,000.

N. Y., Brooklyn—National Saw Dust Co., 69 North 6th St., is receiving bids for the construction of a 2 story, 25 x 100 ft. factory at North 6th St. and East Kent Ave. Estimated cost $40,000. Laspia & Samenfeld, 217 Havenmeyer St., are architects.

N. Y., Maspeth—Circle Flexible Conduit Co., 24-44 Woodward Ave., is having preliminary plans prepared for a 1 story, 94 x 100 ft. factory at Woodward and Flushing Aves. Estimated cost including equipment $40,000. S. Goldsmith, 4914 Church Ave., Brooklyn, is architect.

O., Cleveland—Otis Steel Co., L. C. Parrott, Purch. Agt., 3341 Jennings Rd., awarded contract for the construction of a cold steel rolling mill on Riverside St. to United Engineering & Foundry Co., Farmers Bldg., Pittsburgh, Pa. Estimated total cost $2,000,000.

Tex., Mineola — Dean Lewis & Associates, acquired a site and plans the construction of an oil refinery. Estimated cost $125,000. Owners are in the market for complete equipment, etc.